# First results of the optical speckle interferometry with the 3.5-m telescope at Calar Alto (Spain): Measurements and orbits of visual binaries

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**Abstract** We present the first results of optical speckle interferometry of visual binaries obtained with the 3.5-m telescope at Calar Alto (Almería, Spain) in July 2005. During this campaign fifty stars were observed with angular separations between $0''.058$ and $2''.1$. New orbits for binaries COU 490 and A 2257, and improved orbits for COU 606, A 225, A 2189, COU 1785, COU 2416, and COU 327 AB, along with their systemic masses were calculated. The first estimations of distance for the COU 490 (145 pc) and the A 2257 (210 pc) were accomplished thanks to the previously obtained dynamical parallaxes and to the known spectral and photometric data. Total masses for systems with both new and improved orbits are given, those being concordant with their known spectral types and photometric data. We conclude that with the 3.5-m telescope we can routinely obtain good optical speckle data for binary systems with angular separations close to its diffraction limit.

## 1 Introduction

The high-quality astrometric data obtained close to the diffraction limit of the telescope by means of the speckle interferometry allow us to calculate very accurate orbits of binary systems. Furthermore, it is well known that this procedure represents a direct and reliable method for obtaining dynamical masses of stars. The

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knowledge of this fundamental parameter provides insight into the binary formation mechanisms and improves our understanding of the astrophysics in these systems.

In this way, we have performed several runs by using our optical ICCD speckle camera with the 1.52-m telescope of the Observatorio Astronómico Nacional located at the Centro Astronómico Hispano-Alemán (CAHA, Almería, Spain).

Now, thanks to the observation time at our disposal with the 3.5-m telescope of CAHA (July 2005), new orbits as well as improved ones for six other binaries were calculated. Moreover, systemic masses for all pairs and first distance estimates for COU 490 and A 2257 were also obtained. More detailed results of this run of speckle interferometric observations of 50 double stars is available in [10].

## 2 Observations

The speckle camera description, the observation techniques and the reduction procedure are explained in detail in the papers derived from the previous observational runs at CAHA in 1999 [9], 2000 [7], and 2001-2004 [8]. In the last run (July 2005, [10]) the observations were routinely performed using the 520/24 nm filter and 20× magnification of the microscope objective. The total field of view was about $2''\!.5$ and the pixel scale was about $0''\!.0046$ pix$^{-1}$. A picture of the camera attached to the 3.5-m telescope is shown in Fig. 1.

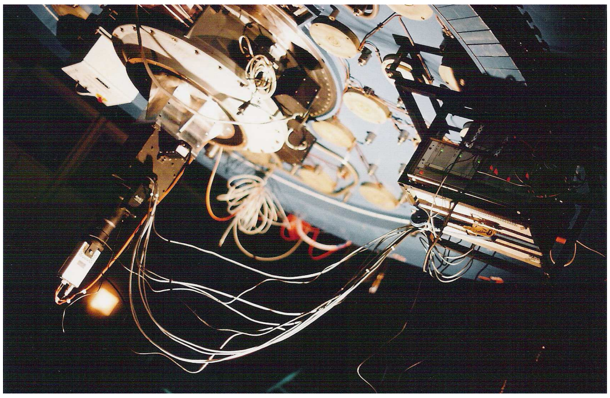

**Fig. 1** Our speckle camera attached to the 3.5-m telescope at Calar Alto.

In contrast with previous runs, data reduction was accomplished by taking advantage of the data storage and computing services of the Supercomputing Center of Galicia (CESGA). With this aim, we extensively used the Galician Virtual Supercomputer (SVG) system which comprises 200 Intel Pentium III/4 processors with a peak performance of 528 Gflops running under Linux OS. A large amount of processing time was saved, and we hope it can be further shortened in the future.

Calibration was done by observing binaries with high-quality orbits taken from the list of calibration stars catalog supplied with the 2005 version of the Sixth Catalog of Orbits of Visual Binary Stars [11]. For example, Fig. 2 shows the autocorrelation function of the BU 989 AB calibration system. The weighting scheme, based on the telescope aperture and observing technique, described in [5] and [14] for visual and speckle data respectively was applied.

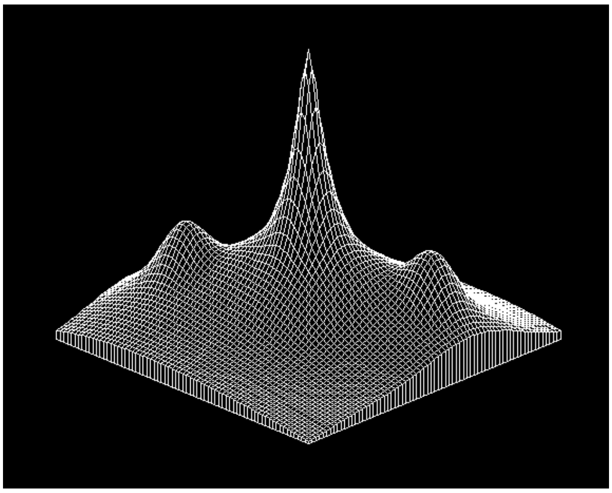

**Fig. 2** Autocorrelation function for the BU 989 AB system.

In all, astrometric data for 50 stars were obtained under good seeing conditions between $1\overset{''}{.}1$ and $1\overset{''}{.}5$. They have been already published in [10]. A wide range of separations between $0\overset{''}{.}058$ and $2\overset{''}{.}100$ has been covered. A histogram with the amount of systems observed for each angular separation interval is shown in Fig. 3.

In general, the observations confirm that high-quality optical speckle interferometry data can be obtained with the 3.5 m telescope of CAHA. In view of successful results, we intend to use this telescope for follow-up observations of close binary and multiple systems of special astrophysical interest. Moreover, with better seeing conditions, the diffraction limit can possible be reached.

## 3 Orbits and masses

For a number of stars the measurements show a systematic departure of positions from those predicted by previous orbital solutions. The Docobo's method [4] was used in orbital calculations. With the aim of better adjusting the orbits to the obser-

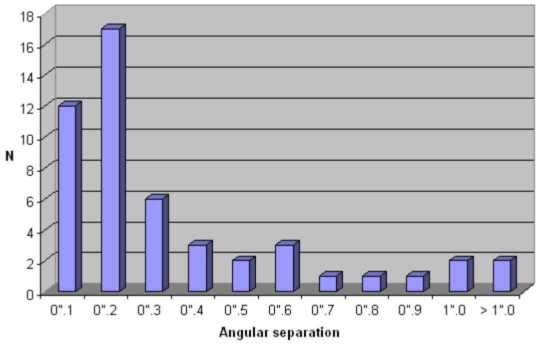


**Fig. 3** Measurements histogram.

vations, we improved them for six binaries (COU 606, A 225, A 2189, COU 1785, COU 2416, and COU 327 AB). Besides this, the first orbits for COU 490 and A 2257 were calculated. All orbits were previously announced in the IAU Commission 26 Information Circulars No. 160, 161 and 162.

Outstandingly, new measurements, used to calculate or to improve the orbits, are generally situated at critical points of their apparent orbit: close to periastron, near the position of minimal apparent separation or barely observed parts of orbits.

In the following, we briefly present comments on one star with an improved orbit and one star with a newly calculated one. Figs. (4) and (5) show the scale on both axes in arcseconds. Each measurement is connected to its predicted position by an O−C line. The dashed line passing through the primary star is the line of nodes. The points and stars represent visual and speckle measurements respectively, and the arrow shows the direction of orbital motion. Finally, measurements obtained in the last run (July 2005) are enclosed in circles.

### *3.1 First orbit of A 2257*

This star (WDS 18044+0337) is not included in the *Hipparcos* main catalog. The WDS catalog gives 9.8 mag and 10.0 mag for its main and secondary components respectively and combined spectral type F5, whereas the Tycho-2 Spectral Type Catalog [15] assigns the F2/3 spectral type and $B-V = 0.425$ mag to this star. Using our measurement a first orbit was calculated by Docobo and Tamazian [6].

The application of Baize-Romani's method ([3] and [12]) (assuming combined spectral type F2V) leads to dynamical parallax $\pi_{dyn} = 0\farcs00473$ (distance 210 pc) and a dynamical mass of $2.9M_{\odot}$. More speckle measurements are needed in the future to better define the part of the orbit close to periastron (see Fig. 4).

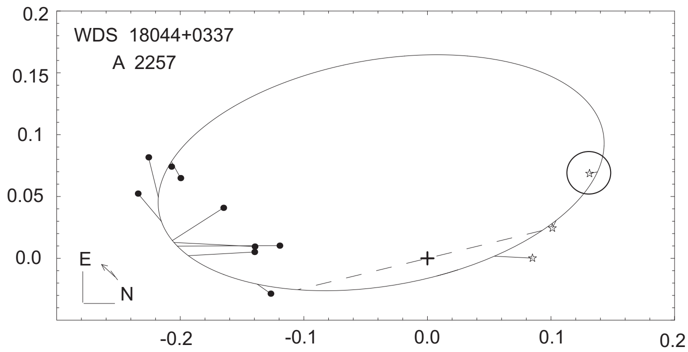


**Fig. 4** Apparent orbit of A 2257.

### *3.2 Improved orbit of A 225*

This binary system (WDS 16198+2647), with apparent magnitudes of 10.04 and 9.79, was first resolved in 1901 by Aitken [1]. Although it has already completed about two revolutions since its discovery, until recently the set of available measurements from 1901 to 1991 covered an orbital arc of only 50°. During our observational run, we obtained a new measurement placed at the opposite side of orbit and very close to the periastron (see Fig. 5).

The previous orbit was calculated by [13], who obtained a period of 44.0 yr, a semi-major axis of 0.″113, and an eccentricity of 0.64. Our measurement gives residuals of −5.°3 and 0.″030 in position angle and angular separation, respectively. Using our near-periastron measurement, a new, less eccentric orbit, was calculated by Andrade [2].

Dynamical parallax of 0.″00787 and component masses of 1.14 $M_{\odot}$ and 1.21 $M_{\odot}$ are obtained by using Baize-Romani's method ([3] and [12]). In good agreement with these results, the parallax $0.''00764 \pm 0.''00126$ measured by *Hipparcos* leads to a semi-major axis of $16.9 \pm 2.9$ AU and a total mass of $2.6 \pm 1.3$ $M_{\odot}$ (95.7% of uncertainty is caused by the large uncertainty of the *Hipparcos* parallax). According to [13], who obtained the same mean value, the computed dynamical mass suggests an evolved pair.

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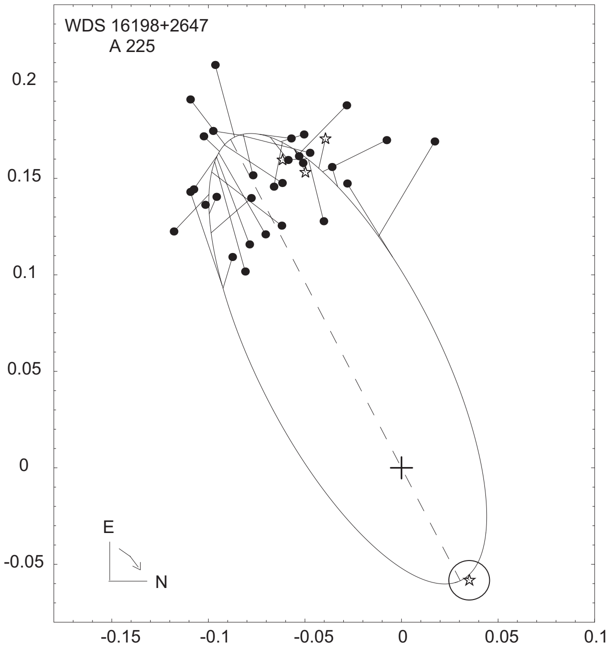


**Fig. 5** Apparent orbit of A 225.

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