RevMexAA (Serie de Conferencias), **21**, 75–76 (2004)

INFRARED DIFFERENTIAL PHOTOMETRY OF SELECTED ORBITAL BINARIES[1]

Patricia Lampens,[2] Jean-Louis Prieur,[3] and Robert Argyle[4]

RESUMEN

Hemos efectuado observaciones de alta resolución angular para estrellas binarias cercanas de tipo F-G y K usando la técnica de óptica adaptativa - el instrumento ADONIS - y el telescopio ESO de 3.6m del observatorio de La Silla. La meta es obtener índices de color con los filtros (J,H,K) para las componentes individuales de aquellas binarias que no se ajustan a la relación media masa-luminosidad, pero que tienen paralajes exactas y órbitas de alta calidad. Las mediciones de los índices de color permiten la determinación de las temperaturas individuales y de los cocientes de masa

ABSTRACT

High-angular resolution observations were acquired for a sample of F-G and K nearby orbital binaries, making use of the ADONIS instrument mounted at the 3.6m ESO telescope from La Silla observatory. The aim is to derive broad-band near-infrared colours for the individual components of those binaries which do not fit well the mean mass-luminosity relation, but which have accurate parallaxes (from the Hipparcos satellite) and high-quality orbits, thanks to many previous efforts. Such colour determinations allow component temperatures and photometric mass ratios to be derived.

Key Words: **BINARIES: VISUAL — STARS: FUNDAMENTAL PARAMETERS — TECHNIQUES: HIGH-ANGULAR RESOLUTION**

1. INTRODUCTION

Visual binaries with significant orbital motion still deserve our attention today. Although the requirement of obtaining astrophysically interesting stellar mass determinations (with component mass errors of 1-2% according to Andersen 1991), is more difficult to meet for the lower mass systems than for the higher mass systems (e.g. eclipsing binaries) due to their much longer periods and different observing technique, the study of such binaries remains important for the following reasons:

- they represent a different fraction of the binary population as they carry a lot of angular momentum;
- the less massive visual binaries consist of non-interacting components with the same evolutionary scenario as single stars;
- on the lower branch of the Main Sequence they are the only objects that allow a direct calibration of the mass-luminosity relation.

For many visual binaries with subarcsecond separation the Hipparcos mission provided a first measurement of the differential magnitude, ΔH_p (ESA 1997), except for the ones with very short ($P < 30$ yr) orbital periods (Martin & Mignard 1998). Even so there is a lack of colour information for the components of such binaries: the existing spectral classifications refer to the systems as a whole; nevertheless when component spectral classifications are quoted, they usually rely on a *visual* estimation of Δm accurate within ± 0.2 mag (Christy & Walker 1969; Edwards 1976) while the recent Tycho Double Star Catalogue provides ΔB_T and ΔV_T only if $\rho > 0.5''$ and $\Delta m < 3$ (Fabricius et al. 2002). Therefore, the current paradox is that the most accurate masses, derived from visual binaries, come from stars with the largest uncertainties in their colours.

Our goal is to obtain the component colours from a single observation using the technique of adaptive optics (A.O.), which allows resolution of components well below the usual limit imposed by the seeing, in order to: (a) characterize each component in terms of T_{eff} and/or chemical composition, (b) derive bolometric corrections and magnitudes (a function of temperature and metallicity), (c) provide an independent determination of the mass ratio.

2. DESCRIPTION OF THE SAMPLE

We focussed on a list of fifty bright, close visual binary targets which satisfy the following criteria:

[1] Based on observations made at ESO (P66.D-0538)

[2] Royal Observatory of Belgium, Brussels, Belgium. (patricia.lampens@oma.be)

[3] Observatoire de Midi-Pyrénées, Toulouse, France.

[4] Institute of Astronomy, University of Cambridge, United Kingdom.

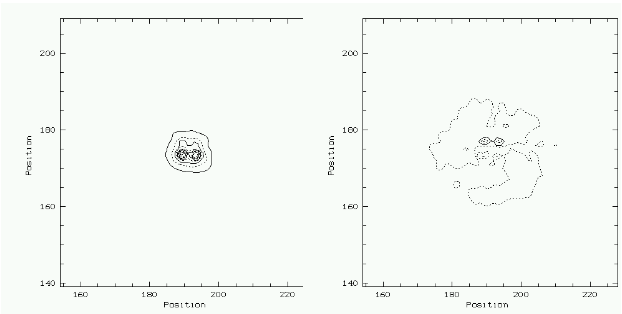

Fig. 1. Contour plot of the original (left) and residual (right) intensity distributions for HIP 25550

- nearby visual binaries for which the combination of the accurate Hipparcos parallaxes with high-quality orbits allows component masses with accuracies better than 8-10% to be derived, with predicted angular separations between 0.1″ and 1″, with orbital periods ranging from 2 to 700 yr and total masses from 0.4 to 8 $M_\odot$. The accuracies are based on a catalogue of orbital parameters with realistic errors computed by means of the statistical method of bootstrapping (Ruymaekers 1999). Note that most of those systems are outliers that do not fit the mean mass-luminosity relation (Lampens et al. 1997).

- 27 binaries with $P \leq 29$ yr for which new astrometric mass ratios were derived (Table 1, Söderhjelm 1999), but not always consistent with a first computation (Martin & Mignard 1998).

3. OBSERVATIONS

The observations were obtained during two nights (13-14 and 14-15 Dec 2000) with the ESO 3.6 m telescope at La Silla. The telescope was equipped with ADONIS and the Sharp II+ infrared camera. We used a lens with a scale of $\sim 0.050''$/pixel and the ESO filters J, H, and K.

The seeing conditions (FWHM ∼1-2″) were more stable during the first night, which explains why A.O. performed better on that night, leading to a higher detection rate. We resolved 17 objects out of the 20 binaries observed on the first but only 11 out of 17 on the second night.

4. DATA REDUCTION

The reduction steps consist of the bad pixel correction (with darks), sky-subtraction and flat-field division (using sky flats at twilight) making use of the Eclipse software provided by ESO (Devillard 1997). We used a profile fitting algorithm based on the 2-dimensional Moffat-Lorentz profiles (Cuypers 1997) in the case of clearly resolved binaries. Figure 1 shows a contour plot of the original and residual intensity distributions in the well-resolved case of HIP 25550. For all other cases, we performed a Fourier analysis of the power spectrum of the images. We calibrated the transfer function of the imaging system with observations of an (unresolved) PSF reference star within ∼5° from the target. The ratio of the corresponding power spectra exhibits fringes when two or more stars are detected (e.g. Fig. 2). We applied the scale and orientation calibration derived by Berthier et al. (2002) at the same epoch. Details will be published elsewhere.

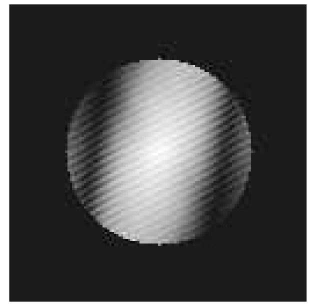

Fig. 2. Power spectrum of the triple system HIP 7372 ABC.

5. CONCLUSION

We aim at obtaining component colour indices for our binary targets by combining the total J, H, K magnitudes calibrated through standard star observations with the observed differential colours. The component colours will then be used to characterize each component in terms of astrophysical parameters such as e.g. T_{eff} and chemical composition. They will also serve to determine absolute bolometric magnitudes and (photometric) mass ratios.

REFERENCES

Andersen, J. 1991, A&A Rev., 3, 91
Berthier, J., Marchis, F., Fienga, A., & Descamps, P. 2002, http://www.bdl.fr/priam/adonis
Christy, J. W., & Walker, R. L. 1969, PASP, 81, 643
Cuypers, J. 1997, ASSL 223, ed. J. A. Docobo, A. Elipe & H.A. McAlister (Dordrecht: Kluwer), 35
Devillard, N. 1997, The ESO Messenger, no. 87
Edwards, T. W. 1976, AJ 81, 245
ESA 1997, The Hipparcos and Tycho Catalogues, ESA-SP 1200, Vol. 1
Fabricius C., Hog, E., Makarov, V. V. Mason, B. D., Wycoff, G. L., & Urban, S. E. 2002, A&A, 384, 180
Lampens, P., Kovalevsky, J., Froeschlé, M., & Ruymaekers, G. 1997, Proc. JD 14, IAU GA XXIII, Kyoto '97
Martin, C., & Mignard, F. 1998, A&A, 330, 585
Popper, D. 1980, ARA&A, 18, 115
Ruymaekers, G. 1999, Ph. D. thesis, K.U.Leuven
Söderhjelm, S. 1999, A&A, 341, 121