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Speckle interferometry of nearby multiple stars. II.⋆,⋆⋆

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Abstract. This paper is a continuation of diffraction-limited speckle interferometry of binary and multiple stars carried out at the 6-m telescope of the Special Astrophysical Observatory in Zelenchuk. The program has concentrated on nearby ($\pi > 10$ mas) close binaries discovered or measured during the Hipparcos mission. Here, we present 132 measurements of relative positions and magnitude differences for 99 pairs and 8 measurements for 6 triple systems. 54 entries in the paper are new Hipparcos binaries. New triple systems with late-type dwarf components, discovered in the course of observations, are HIP 8533 and HIP 25354.

Key words. stars: binaries (including multiple): close – techniques: interferometric

1. Introduction

This paper continues the presentation of the results of binary and multiple star speckle interferometry based upon observations made at the 6-m BTA telescope of the Special Astrophysical Observatory in Zelenchuk. Precise speckle measurements of binary stars carried out over many years remain the main effective source of orbital parameters. Most of our program objects are nearby low-mass main-sequence stars discovered or measured by Hipparcos. The purposes of this study are: (1) to select new pairs exhibiting relatively fast orbital motion; (2) to derive the orbital elements of the newly discovered pairs; (3) to obtain accurate magnitude differences for the components of binary and mutiple systems. Together with the Hipparcos parallaxes and differential magnitudes, the orbits allow the estimation of mass sums of the components, their luminosities, and spectral types. The mass ratios, period, and eccentricity distributions can be studied for our sample stars.

2. Observations and results

The observations presented here were obtained in October 1999 using the new speckle camera developed in 1998 (Maksimov et al. 2003). The first results from the speckle program with this new instrument were reported in Balega et al. (2002, hereafter B02).

The image motion-compensated seeing (FWHM) during the observations was 1.″0–1.″5. Filters with the following center wavelength/bandwidth were used: 545 nm/30 nm (centre of the V-band), 610 nm/20 nm, and 800 nm/60 nm (R-band). In the following, they are designated as V', G', and R'.

Relative positions and magnitude differences of each binary were derived from the ensemble averaged power spectrum of speckle interferograms without compensation for the atmospheric transfer function. The magnitude difference between the components of a binary was estimated from the contrast of the fringes measured at different circle radii of the power spectrum (see B02). The 180° ambiguity of the position angle θ was overcome by the Walker method (Walker 1981).

A double-slit pupil mask was used for direct calibration of the measurements. In addititon, an independent calibration was performed by observations of standard speckle interferometric binaries with slow orbital motion.

Table 1 contains 132 measurements of 99 binary stars. The entries for each system are presented in the same condensed format used in B02. Columns 1 through 3 list the designation of the system. Column 1 is the Hipparcos number (ESA 1997), Col. 2 gives the name of the star or its catalog number, Col. 3 lists the discovery designation. The next columns contain the epoch-2000 coordinates, the epoch of observations given as the fractional Besselian year. They are followed by the measured position angles θ given in degrees, angular distances ρ

⋆ Based on data collected at the Special Astrophysical Observatory, Russia.

⋆⋆ Tables 1–3 are only available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/cgi-bin/qcat?/A+A/422/627

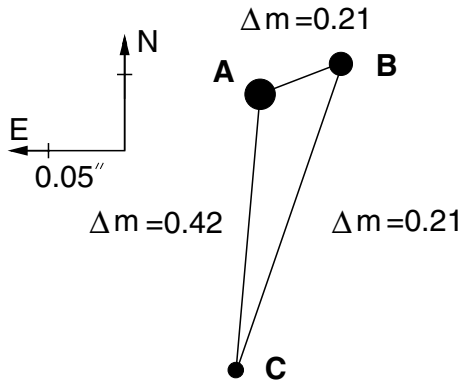

Fig. 1. Geometry of the triple system HIP 8533. The size of the circles corresponds to relative brightness of the components.

in mas, and their errors. The θ values have not been corrected for precession and are thus based upon the equinox for the epoch of observation. Magnitude differences Δm, together with their errors, are listed in Cols. 10 and 11. The final column gives the filter designation as described above. Note that in the discovery designation column the HDS (Hipparcos Double Stars) numbers are included, following the upgraded daily Washington Double Star Catalog, maintained at the US Naval Observatory (Mason et al. 2003). The table lists 53 HDS entries, of which 16 have been observed by speckle interferometry for the first time.

The measured angular separations in Table 1 range from a minimum value of 16 mas for the close binary HR 233 to 1859 mas for the components of HIP 103767. In speckle interferometry the accuracy of the measurements is a function of many parameters: seeing, stellar magnitude, magnitude difference, angular separation, etc. For most of our data the typical value of the error is 0.5–2 mas in ρ and 0.2–0.5° in θ. This corresponds to a relative error of the vector measurements in the range 0.1–2%; however, in some cases of very close pairs, the error can reach 10% (see e.g. HIP 17932 = CHR 126 with ρ = 21 mas).

For 25 systems, indicated by an asterisk following their θ values, the 180° position angle ambiguity was not resolved.

111 magnitude differences for 92 binaries are given in Table 1. The mean-square errors of Δm measurements vary widely from $0.01^{\rm m}$ to $0.75^{\rm m}$, corresponding to different conditions of observation. In 12 cases, indicated by colons, the Δm measurements are uncertain, while for 7 pairs no Δm value is given. In all these cases, except α Aur, the binaries were too wide to fit the entrance window of the detector.

Measurements of 6 triple systems are listed in Table 2. For all the systems the angle θ is given starting at the position of the brighter component. To avoid possible confusion in the components' identification, we designate them as A, B, C, according to their relative brightness. Additional components to known binaries were discovered in HIP 8533 and HIP 25354. The reconstructed geometry and differential magnitudes of HIP 8533 are shown in Fig. 1. A third companion close to the primary star is also suspected in the M 2 type binary HIP 39402. Specific notes concerning the measured triple systems are given in Sect. 2.1. The close spectroscopic subsystem BAG 15 (B02) in the triple system HIP 111805 was not resolved during the 1999 run; therefore, it is given as a Table 1 entry. Three triples, ADS 14749, ADS 16214, and ADS 16904, with early spectral type components, were included in the program as speckle interferometry calibration targets.

For 32 Hipparcos pairs absolute magnitudes and spectral types of the components were estimated using our Δm measurements, Hipparcos parallaxes, and Hipparcos median magnitudes *Hp*. Spectral types for luminosity class V were taken from (Lang 1992). The results are presented in Table 3. For three pairs (HIP: 93119, 94960, and 103067) the absolute magnitudes do not correspond to $(B - V)$ and $(V - I)$ colors of main sequence stars. The increased luminosity of these binaries can be caused by the presence of a third companion or by the evolved status of the companions. The values in Table 3, combined with 63 values from the first paper of the program, give a total of 95 absolute magnitudes and spectral types of the components.

2.1. Notes to triple systems

HIP 8533. The system was included in the observing list as a component solution binary of the Hipparcos Catalogue (ESA 1997). Until then, there was only one measurement of the star, by Muller (Worley & Douglass 1997), who resolved it as a binary (MLR 297) with ρ = 300 mas and Δm = 0.8. We found the star to be a triple system with a low level of hierarchy: the ratio between the short and the long vector is 0.26. Based on the Hipparcos parallax of the system, we define absolute magnitudes of the three components: 5.8, 6.0, and 6.2, corresponding to spectral types G8 and K0.

HIP 25354. A new triple star with high hierarchy. The main component is a K8 star, while the secondary is a double with M type components. Because of the large separation between the A star and the BC, the magnitude differences for A-B or A-C cannot be measured with our camera.

HIP 39402. An additional component at a distance of 40 mas from the secondary is suspected in the system. The magnitude difference is between 1.5 and 2 mag.

HIP 101955. This observation confirms the fast orbital motion of the spectroscopic subsystem BAG 14. Differential magnitudes and estimated absolute magnitudes agree with the observations of the previous year.

HIP 116726. In B02 the measurement for CHR 149 was erroneously given as for the AC component. The correct entry is: CHR 149 = BC, $\theta = 43.1° \pm 2.0°$.

3. Summary

We continue the speckle study of binaries discovered by Hipparcos and other nearby low-mass systems. The aim is to select binaries with fast relative motion in order to determine new orbits and to combine the Hipparcos parallaxes with the speckle interferometric Δm measurements to derive absolute magnitudes and spectral types of the components.

The presented sample of stars includes 54 new Hipparcos doubles with parallaxes above 10 mas and separations of less

than $\sim 1''$. Of these, 17 have been observed in 1999 by speckle interferometry for the first time. Two new triple systems were discovered among the objects of the program: HIP 8533 and HIP 25354. For 32 new Hipparcos pairs, absolute magnitudes and spectral types of components were derived from our Δm measurements and Hipparcos parallaxes under the assumption that the components are the main-sequence stars.

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