The A-Star Puzzle
Proceedings IAU Symposium No. 224, 2004
J. Zverko, J. Žižňovský, S.J. Adelman, & W.W. Weiss, eds.

DOI: 10.1017/S1743921305009579

Speckle interferometry of the binary system 53 Cam

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The study of orbital parameters of multiple Ap stars may lead to new suggestions about the origin and magnetic properties of the components. 53 Cam is one of the best studied binaries among Ap stars. However, the nature of its secondary star remains unclear despite the wealth of spectroscopic observations. The system was first directly resolved by speckle interferometry method in 1980 at the 4 m KPNO telescope McAlister *et al.* (1983). The authors supposed that the magnitude difference between the components could be close to zero. From that time, 16 speckle measurements of the system were made, including 7 observations collected with the SAO 6 m telescope. In addition to relative positions of the components, speckle observations from the 6 m telescope provide high accuracy magnitude difference estimates.

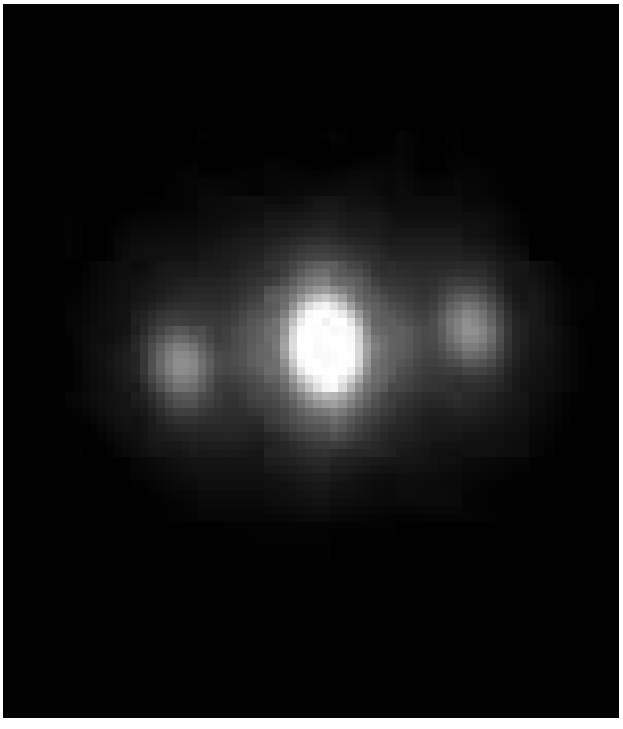

Figure 1. Autocorrelation function of 53 Cam obtained from 1500 speckle interferograms: the separation between the central and the secondary peak corresponds to an angular distance of 74 mas between the components.

One of the reconstructed autocorrelation function of the binary in $\lambda/\Delta\lambda = 545/25$ nm filter is shown in Fig.1. The most particular feature of these measurements is the first

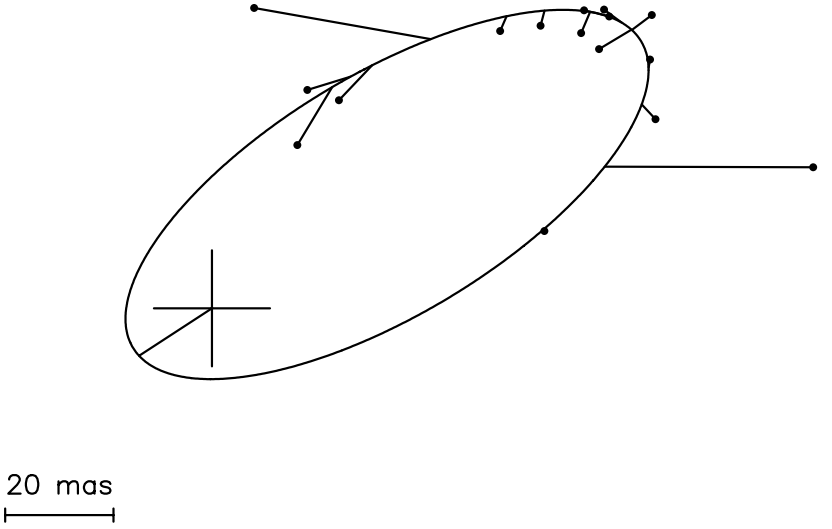

Figure 2. Relative visual orbit of 53 Cam calculated using both the interferometric and spectroscopic data. Speckle measures are connected to their predicted positions on the orbit. Two measurements with very large deviations from the ephemeris were not taken into account in the calculations. Typical error bar of speckle measurements is in the range 2-4 mas. North is up, east to the left.

direct magnitude difference estimate obtained from the reconstructed power spectrum of 1500 speckle interferograms with photon and detector bias removed. The fringe contrast of the power spectrum of speckle images in V-band yields:

$$\Delta m = 1.20 \pm 0.10.$$

To derive the combined spectroscopic/interferometric orbit we have fitted simultaneously all available radial velocities and 14 speckle observations. Two our latest speckle measures have been used in the calculations:

1997.9692 303.7° 98 mas
1999.2429 313.9° 74 mas

The resulting orbital parameters are given in Table 1, and the corresponding visual orbit is shown in Fig.2.

Table 1. Orbital elements for the combined spectroscopic/interferometric solution.

P	6.6504	±	0.0089 yrs
T	2001.2281	±	0.025
e	0.706	±	0.024
a	0.055	±	0.018 mas
i*	55.4	±	2.9°
Ω	118.3°	±	20.1°
ω	8.3°	±	1.8°
$K1$	12.6	±	1.2 km/s
$V0$	-2.3	±	0.2 km/s

Note: The i*-value is given for purely speckle interferometric solution. The consideration of spectroscopic data leads to i=55.4 ± 93.4° with the inadmissible error bar.

https://doi.org/10.1017/S1743921305009579 Published online by Cambridge University Press

Our orbital parameters and the scatter of the residuals of speckle measurements are consistent with those reported by Hartkopf *et al.* (1996) and Carrier *et al.* (2002). Using the Hipparcos parallax of 53 Cam, $\pi = 10.16 \pm 0.77$ mas, we obtain the orbital mass-sum of the binary:

$$\sum M = (3.61 \pm 0.38)\ M_{\odot}.$$

The parallax error remains the principal error in the mass determination. From the measured magnitude difference it follows that the absolute visual magnitude of the main component of 53 Cam is 1.37. Such absolute luminosity corresponds to an A2 dwarf. The luminosity of the primary, $L/L_{\odot} = 21.7$, is close to the estimate made by Kochukhov *et al.* (2004). The secondary star in the system is most likely an F0V star with an absolute magnitude of 2.57. Its contribution to the total spectrum is only 1/3 of the primary. Note that the mass-sum for a pair of main-sequence A2 and F0 stars is about 4.2 $M_{\odot}$ (Lang 1992), which is notably larger than the orbital mass-sum 3.61 $M_{\odot}$.

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https://doi.org/10.1017/S1743921305009579 Published online by Cambridge University Press