Speckle interferometry of two low-mass triple systems in the solar neighbourhood

E.V. Malogolovets[1], Y.Y. Balega[2], K.-H. Hofmann[3], D.A. Rastegaev[4] and G. Weigelt[5]

[1] Special Astrophysical Observatory Russian Academy of Sciences `evmag@sao.ru`
[2] Special Astrophysical Observatory Russian Academy of Sciences `balega@sao.ru`
[3] Max-Planck-Institut fuer Radioastronomie `khh@mpifr-bonn.mpg.de`
[4] Special Astrophysical Observatory Russian Academy of Sciences `leda@sao.ru`
[5] Max-Planck-Institut fuer Radioastronomie `weigelt@mpifr-bonn.mpg.de`

1 Introduction

Multiple systems with low levels of hierarchy are important targets for the study of formation, evolution, and dynamical stability of multiple stars. Two such triple stars with low mass components, GJ 900 and KUI 99, have been observed during the last six years at the 6 m BTA telescope (Zelenchuk). The first object is a young system with projected distances between the components in the range of 200-700 mas. The second one is a group of middle-aged K dwarfs.

In the V and I bands, the observations were performed using the speckle camera described in [7]. In the K-band the data were obtained with the speckle camera of the Max-Planck-Institut fuer Radioastronomie in Bonn. The mean square error of the speckle measurements is 2-4 mas, depending on seeing conditions. The speckle images were reconstructed using the triple correlation method [6]. Below, we present the results of the relative motion study in the systems and give conclusions about their hierarchy.

2 GJ 900

GJ 900 is a young nearby (π_{hip}=51.8 mas) K7 star. It was first resolved as a triple system with speckle interferometry at the 6 m BTA telescope in November 2000. The bispectrum reconstruction of the K-band image is shown in Fig. 1. Later, the system was observed in the H and K bands with the 8 m Subaru telescope using adaptive optics [8]. From the apparent configuration of the components, it was supposed that it could be a low-mass Trapezium-type system. If this is the case, GJ 900 is the first known Trapezium-type star at the bottom of the main sequence.

Presently, 4 speckle interferometric observations and 2 adaptive optics measurements allow us to follow the relative motion of the components. Speckle photometry gives the following magnitude differences between the stars: $\triangle I_{AB}$=2.42±0.08, $\triangle I_{AC}$=3.67±0.22, $\triangle K_{AB}$=1.92±0.18,

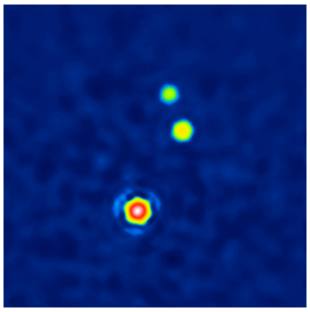

Fig. 1. The bispectrum reconstruction of the GJ 900 image in the K-band.

$\triangle K_{AC}$=2.55±0.30. These differences are approximately 0.2 mag larger than those given by adaptive optics. With magnitude differences in the I-band and Hipparcos parallaxes in hand, we obtain the following absolute magnitudes for the components: M_{IA}=10.5, M_{IB}=12.9, M_{IC}=14.2. The corresponding spectral types of the individual stars are: K7, M5 and M7.

The relative positions of the AB pair changed linearly during the period 2000-2004, showing a mean value of 48 mas/yr (Fig. 2). The angular separation in the AC pair remains constant within the errors of measurements. These observations are represented in Fig. 3. We expect that the period of the AB pair lies between 50 and 100 yrs, while for the AC subsystem it can be over 1000 yrs. It looks as if the GJ 900 apparent configuration is caused by a chance projection.

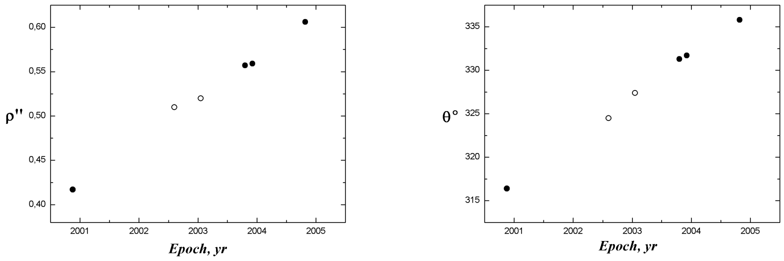

Fig. 2. Relative positions for GJ 900 AB between 2000.8754 and 2004.8208. Filled circles are from the 6 m BTA speckle measurements; open circles are the adaptive optics data from Martin [8].

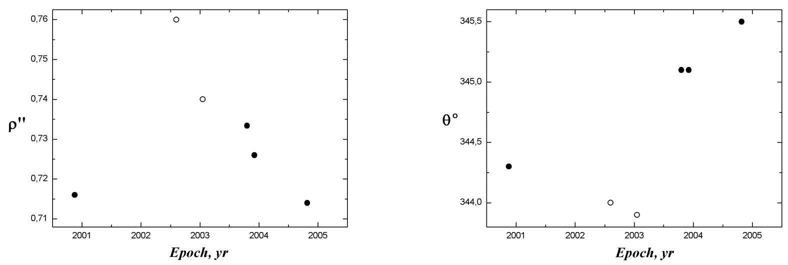

Fig. 3. Relative positions for GJ 900 AC between 2000.8754 and 2004.8208.

3 KUI 99=GJ 795

KUI 99 is a late-type K star from the solar neighbourhood (π_{hip}=53.82 mas). In 1943, Kuiper [5] first resolved KUI 99 as a visual binary star. Duquennoy [3] found that the brighter component of KUI 99 is itself a spectroscopic binary. Orbital solutions for the outer pair were proposed by Baize [1], Heintz [4] and Soderhjelm [10]. In 1998, KUI 99 was directly resolved as a triple star for the first time using the speckle interferometer at the 6 m BTA telescope [2]. The differential magnitude speckle measurements showed that the components B and C have similar brightness: $\triangle m_{AB}$=0.94±0.03, $\triangle m_{AC}$=1.14±0.03. Differential speckle photometry and Hipparcos parallax give the following absolute magnitudes and spectral types for the stars: M_{VA}=7.2, M_{VB}=8.1, M_{VC}=8.3 and K4, K7 and K8.

Interferometric orbits for the AB and AC pair can be derived from the 1998-2004 data. The apparent ellipses of the KUI 99 AC and KUI 99 AB pair are shown in Fig. 4

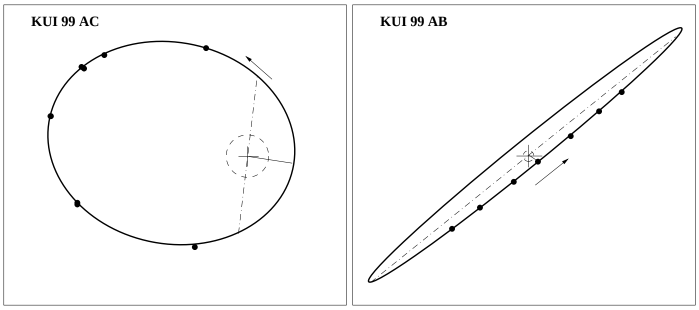

Fig. 4. Speckle interferometric orbits for the inner (KUI 99 AC) and the outer (KUI 99 AB) pair. The line of nodes is shown by the dash-dotted line. The arrow shows the direction of motion. North is up, east is to the left. The dashed circle has a radius of 20 mas.

For the inner AC pair the speckle orbit parameters are in good agreement with the spectroscopic orbit of Duquennoy [3]. The orbital elements for the inner and outer subsystems are given in Table 1.

Table 1. Orbital elements for the inner (KUI 99 AC) and outer (KUI 99 AB) pair.

Comp.	P(yr)	T	e	a($''$)	i°	Ω°	ω°
AC	2.51 ± 0.01	2000.55 ± 0.01	0.620 ± 0.006	0.120 ± 0.002	18.2 ± 2.5	173.6 ± 10.9	87.1 ± 10.3
AB	39.55 ± 0.37	2001.83 ± 0.07	0.161 ± 0.075	0.690 ± 0.074	85.9 ± 0.8	128.6 ± 0.4	92.0 ± 0.8

We can state from the orbital solutions that KUI 99 is a low-hierarchical system with an angle between the two orbital planes of about 70°. It is necessary to continue the monitoring of the relative motion in the systems in order to detect possible oscillations of the orbital parameters, which can be caused by the Kozai mechanizm [9].

References

1. P. Baize: Astron. Astrophys. Suppl. Ser. **44**, 199 (1981)
2. I.I. Balega, Y.Y. Balega, K.-H. Hofmann et al: Astron. Astrophys. **385**, 87 (2002)
3. A. Duquennoy: Astron. Astrophys. **178**, 114 (1987)
4. W.D. Heintz: Astron. Astrophys. Suppl. Ser. **56**, 5 (1984)
5. G.P. Kuiper: Publ. Astron. Soc. Pacific **46**, 285 (1934)
6. A.W. Lohmann, G. Weigelt, B. Wirnitzer: Applied Optics **22**, 4028 (1983)
7. A.F. Maksimov, Y.Y. Balega, U. Beckmann et al: Bull. Special Astrophys. Obs. **56**, 25 (2003)
8. E. Martin: Astron. Journal **126**, 918 (2003)
9. S. Soderhjelm: Astron. Astrophys. **107**, 54 (1982)
10. S. Soderhjelm: Astron. Astrophys. **341**, 121 (1999)