

REVIEW OF CCD OBSERVATIONS OF BINARIES AT NAO ROZHEN

B. NOVAKOVIĆ, R. PAVLOVIĆ and Z. CVETKOVIĆ

Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia

E-mails: bnovakovic@aob.bg.ac.yu, rpavlovic@aob.bg.ac.yu, zcvetkovic@aob.bg.ac.yu

Abstract. In this work we present the review of the measurements of binaries whose frames were obtained using 2-meters telescope at NAO Rozhen in the period from 2004 to 2006. Distributions of measured pairs as functions of separation, the list of pairs measured for the first time, residuals (O-C) in both coordinates (separations and position angles) for those binaries which have had previously published orbital elements and two new orbits are given.

1. INTRODUCTION

Binary stars have been studied for decades for the purpose of accurate determination of stellar masses, verification of the evolutionary models and star formation theories. Washington Double Star Catalog (WDS) contains data for many visual binaries (Mason et al. 2007), but only for a small fraction of them (about 2%) there are orbital solutions. Because of this, as many as possible new observations of double stars should be performed.

Our team has performed three series of CCD observations of visual double and multiple stars at the National Astronomical Observatory (NAO) Rozhen in the period from 2004 to 2006.

The first series of observations performed with a CCD camera attached to the 2-m telescope took place in the middle of October 2004. The telescope is of the Ritchey-Chretien-Coude type with the focal length of 16 m. The frames were obtained by using the Photometrics AT200 CCD camera. The chip dimensions are 1024x1024 pixels, the pixel size is 24x24 micrometers. The angle corresponding to one pixel is 0.31 arcsec. The second series took place in the end of October 2005. The third series took place on December 16/17, 2006. In the second and third series the frames were obtained by using the CCD camera VersArray:1300B. The chip dimensions are 1300x1300 pixels, the pixel size is 20x20 micrometers. The angle corresponding to one pixel is 0.258 arcsec. A total of 129 pairs were measured and the results were published in Pavlović et al. (2005), Cvetković et al. (2006) and Cvetković et al. (2007).

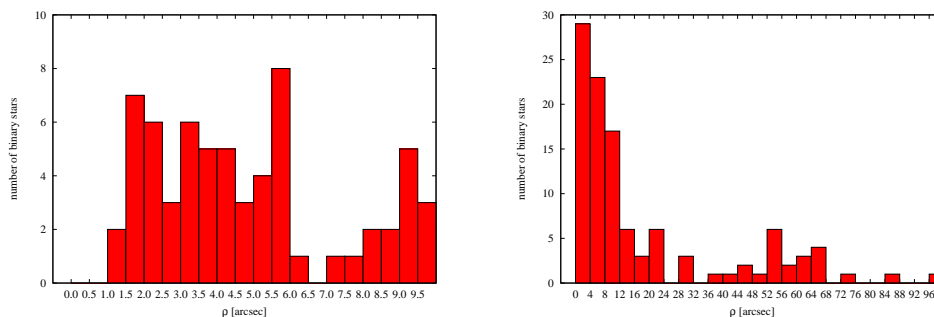


Figure 1: The distributions of separations among the components of 129 pairs observed by our team at NAO Rozhen (all three series are shown).

2. REVIEW

The separations (ρ) between the components of 129 pairs observed by our team at NAO Rozhen, range from 1.38 to 221.01 arcsec. In two histograms presented in Fig. 1. the distributions of separations are given for $\rho \in [0, 10]$ arcsec and for $\rho \in [0, 100]$ arcsec. Although, most of the observed binaries have separations lower than 10 arcsec, only a small fraction of them have separations lower than 2 arcsec. On one hand, this is due to the equipment limitation, but on the other hand we were unable to measure pairs closer than 2 arcsec due to the weather conditions which were not so good, particularly during the second series of observations.

Table 1: The list of pairs measured for the first time.

WDS	Mult.	Discoverer	WDS	Mult.	Discoverer
00057+4549	AQ	Pop	21182+3035	AD	Nov
00057+4549	AX	Pop	21182+3035	AN	Pop
00057+4549	AY	Pop	21182+3035	AX	Nov
00057+4549	Yy	Pop	21182+3035	XL	Nov
02231+7021	AB-C	Cve	21182+3035	XY	Nov
03101+2145	AB-C	Pop	21182+3035	XZ	Nov
03101+2145	AB-D	Pop	21182+3035	XQ	Nov
04159+3142	AB-E	Pop	21182+3035	NK	Pop
04159+3142	AB-F	Pop	22156+4352	AB-C	Pop
21074-0814	AB-E	Pop	22156+4352	CD	Pop
21182+3035	AC	Pop			

Some of the pairs measured in the three series were measured for the first time. The complete list of such pairs is given in Table 1., and it includes 21 pairs which belong to 7 multiple systems. The designations used are: WDS - identification in WDS Catalogue; Mult. - designation for pair components; Discoverer - name of component discoverer (Z. Cvetković (Cve), B. Novaković (Nov) and G.M. Popović (Pop)). It should be noted here that all new pairs belong to multiple systems. As the dynamics of multiple stellar systems is more complex than that of binary stars, multiple systems are particularly important.

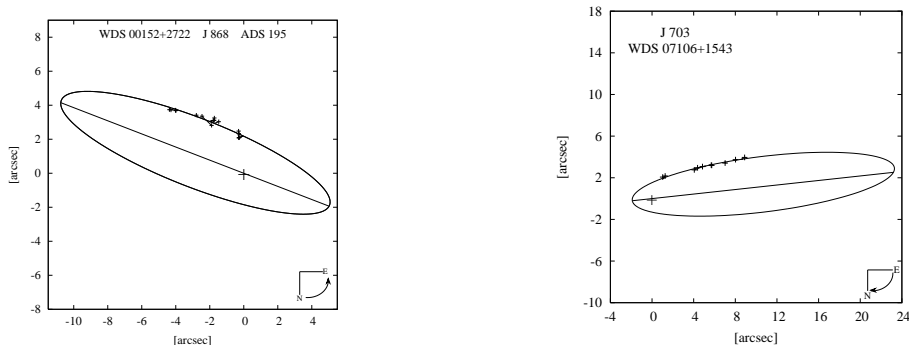


Figure 2: First orbits calculated by authors from Belgrade Observatory including Rozhen measurements as well.

For pairs where the orbits had been previously calculated and the orbital elements were given in the Sixth Catalog of Orbits of Visual Binary Stars (Hartkopf and Mason 2007), the measurements are compared with the ephemerides and the residuals ($O - C$) are given in Table 2. The designations used in Table 2. are: WDS - identification in WDS Catalogue; Mult. - designation for pair components; $(O - C)_\theta$ - residuals in position angles; $(O - C)_\rho$ - residuals in separations.

Table 2: The list of ($O - C$) residuals in the case when orbital solution exists.

WDS	Mult.	$(O - C)_\theta$	$(O - C)_\rho$	Series	Referenes
00057+4549	AB	-0.5	0.06	I	Popović and Pavlović (1996)
00057+4549	AB	0.1	-0.04	I	Kiyaeva et al. (2001)
00057+4549	AB	-0.9	-0.16	II	Popović and Pavlović (1996)
00057+4549	AB	-0.6	-0.26	II	Kiyaeva et al. (2001)
00057+4549	AB	-0.4	0.02	III	Popović and Pavlović (1996)
00057+4549	AB	-0.1	-0.06	III	Kiyaeva et al. (2001)
00152+2722	-	1.4	-0.03	III	Novaković (2007)
00321+6715	Aa-B	-1.0	-0.10	III	Docobo et al. (2006)
07106+1543	-	0.2	0.35	III	Cvetković and Ninković (2008)
08507+0752	-	-1.2	-0.08	III	Mason et al. (2006)
09357+3549	-	9.4	-0.43	III	Heintz (1988)
10110+7508	-	-2.1	-0.22	III	Heintz (1994)
10281+4847	-	-74.6	2.39	III	Hale (1994)
10596+2527	-	0.2	-0.10	III	Kisselev et al. (1997)

Using the measurements obtained by us from the CCD observations at NAO Rozhen we have calculated the first orbits for two binaries. The orbit of WDS 00152+2722 = J 868 was calculated by Novaković (2007), that of WDS 07106+1543 = J 703 by Cvetković (2007). Both orbits have been included in the Sixth Catalog of Orbits of Visual Binary Stars and they are shown in Fig. 2. As the illustration, the CCD frames of these two binaries are shown in Fig. 3.

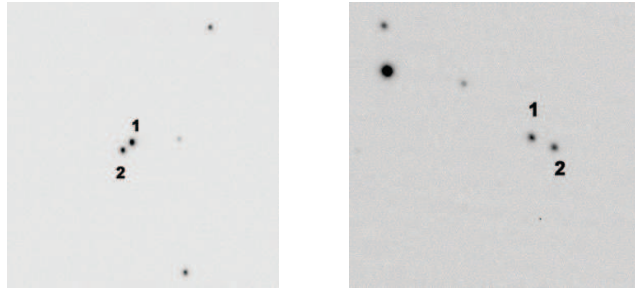


Figure 3: The CCD frame of double star WDS 00152+2722 (left) and WDS 07106+1543 (right) obtained at NAO Rozhen. The components are marked with numbers 1 and 2.

Acknowledgements

The authors are grateful to Prof. Kiril Panov and to the Bulgarian Academy of Sciences for providing observational time at the 2-m telescope. We also acknowledge the support by UNESCO-ROSTE for the regional collaboration. This research has been supported by the Ministry of Science and Technological Development of the Republic of Serbia (Project No 146004 "Dynamics of Celestial Bodies, Systems and Populations").

References

- Cvetković, Z.: 2007, *IAU Commission 26 Inf. Circ.*, **162**.
 Cvetković, Z. and Ninković, S.: 2008, *New Astronomy*, **13**, 587.
 Cvetković, Z., Novaković, B., Strigachev, A., Popović, G. M.: 2006, *Serb. Astron. J.*, **172**, 53.
 Cvetković, Z., Pavlović, R., Strigachev, A., Novaković, B., Popović, G. M.: 2007, *Serb. Astron. J.*, **174**, 83.
 Docobo, J. A., Tamazian, V. S. and Campo, J.: 2006, *Information Circular IAU, Commission 26*, **160**.
 Hale, A.: 1994, *Astron. J.*, **107**, 306.
 Hartkopf, W. I. and Mason, B. D.: 2007, Sixth Catalog of Orbits of Visual Binary Stars, US Naval Observatory, Washington, <http://ad.usno.navy.mil/wds/orb6.html>
 Heintz, W. D.: 1988, *Astron. Astrophys. Suppl. Series*, **72**, 543.
 Heintz, W. D.: 1994, *Astron. J.*, **108**, 2338.
 Kisselev, A. A. Kiyeva, O. V. and Romanenko, L. G.: 1997, Visual Double Stars: Formation, Dynamics and Evolutionary Tracks., Edited by J.A. Docobo, A. Elipe, and H. McAlister. Dordrecht : Kluwer Academic, p. 377.
 Kiyeva, O. V., Kiselev, A. A., Polyakov, E. V. and RafalSkii, V. B.: 2001, *Astronomy Letters*, **27**, 391.
 Mason, B. D., Hartkopf, W. I., Wycoff, G. L. and Holdenried, E. R.: 2006, *Astron. J.*, **132**, 2219.
 Mason, B. D., Wycoff, G. L. and Hartkopf, W. I.: 2007, The Washington Visual Double Star Catalogue, US Naval Observatory, Washington, <http://ad.usno.navy.mil/wds/wds.html>
 Novaković, B.: 2007, *Baltic Astronomy*, **16**, 435.
 Pavlović, R., Cvetković, Z., Olević, D., Strigachev, A., Popović, G. M., Novaković, B.: 2005, *Serb. Astron. J.*, **171**, 49.
 Popović, G. M. and Pavlović, R.: 1996, *Bull. Astron. Belgrade*, **153**, 57.