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Professional paper

CCD MEASUREMENTS OF DOUBLE AND MULTIPLE STARS AT NAO ROZHEN. IV

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SUMMARY: Using the 2 m telescope of the Bulgarian National Astronomical Observatory at Rozhen observations of 30 double or multiple stars were carried out during two half nights on July 20 and 21, 2009. This is the fourth series of measurements of CCD frames of double and multiple stars obtained at Rozhen. In this paper we present the results for the position angle and separation for 23 double and 5 multiple stars (35 pairs) which could have been measured.

Key words. binaries: visual

INTRODUCTION

The previous three series of observations of double and multiple stars performed by the Belgrade team at the Bulgarian NAO Rozhen with a CCD camera attached to the 2-m telescope took place in the middle of October 2004, at the end of October 2005 and in the middle of December 2006, respectively. The results have been published in Pavlović et al. (2005), Cvetković et al. (2006) and Cvetković et al. (2007).

The fourth series comprising observations of 24 double and 6 multiple stars took place on July 20 and 21 (both times before midnight), 2009. The observing programme contained systems for which either the number of measurements was small (less than 10), or which have not been measured after 2000. The telescope is of the Ritchey-Chretien-Coude type with the focal length of 16 m. The frames were obtained by using the CCD camera VersArray:1300B. The chip dimensions are 1300×1300 pixels, the pixel size is 20×20 micrometers. The angle corresponding to one pixel is 0.258 arcsec. For each star pair ten frames were obtained (five frames with each of the two filters B and V).

The observational team at the NAO Rozhen that collected frames for the measurement included: Z. Cvetković and R. Pavlović from Belgrade Astronomical Observatory, and S. Boeva from the Institute of Astronomy of Bulgarian Academy of Sciences.

The position angle and separation were measured for 23 double and 5 multiple stars (35 pairs), whereas in the case of the remaining two, the star images were not visually separated and the measurements could not be carried out. The reasons are the proximity of the components and the limiting capabilities of the CCD camera. For binary WDS 18533+3302 = POP 192 the separation is small, whereas for multiple WDS 15440+0231 = A 2230, the components of the pair AB are close to each other and the magnitude difference is high ($\Delta m \approx 6$) so that we failed to separate them. The other pairs AC, AD and CE have large separations and their

Table 1. CCD Measurements of Double and Multiple Stars

WDS	Disc.	Mult.	Epoch 2009+	$\theta[^\circ]$ (σ_θ)	ρ $['']$ (σ_ρ)	n	Auth.	Notes
16140+3510	POP 103		0.5532	52.87 (1.12)	3.586 (0.238)	43	Cve	
				52.93 (0.83)	3.665 (0.093)	11	Pal	
16284+3112	BRT 255		0.5505	216.92 (0.47)	4.643 (0.090)	71	Cve	N
				216.88 (0.40)	4.465 (0.259)	17	Pal	
16469+0210	BAL1925		0.5532	207.44 (3.08)	1.065 (0.149)	17	Cve	N
				206.73 (3.21)	1.293 (0.278)	9	Pal	
16507+1259	BRT1284		0.5506	301.88 (0.94)	3.302 (0.167)	46	Cve	N
				302.50 (1.00)	2.886 (0.286)	11	Pal	
17201+3225	GCB 28		0.5506	230.42 (1.05)	3.098 (0.332)	32	Cve	
				230.66 (1.21)	2.626 (0.419)	11	Pal	
17222+3010	ROE 108		0.5532	0.97 (0.17)	5.885 (0.014)	46	Cve	N
				0.96 (0.16)	5.891 (0.012)	10	Pal	
17494+2651	BRT3322		0.5533	165.92 (1.25)	4.401 (0.090)	49	Cve	
				164.78 (0.56)	4.230 (0.135)	15	Pal	
18000+2535	HJ 1310	AB	0.5533	42.84 (0.15)	10.206 (0.060)	30	Cve	
				42.90 (0.18)	10.256 (0.039)	10	Pal	
18000+2535	HJ 1310	AC	0.5533	31.66 (0.67)	12.929 (0.142)	29	Cve	
				31.67 (0.50)	13.116 (0.154)	10	Pal	
18000+2535	HJ 1310	BC	0.5533	356.98 (1.65)	3.558 (0.200)	36	Cve	
				358.85 (1.95)	3.804 (0.216)	10	Pal	
18103+2430	POU3355		0.5533	150.65 (0.34)	5.903 (0.022)	41	Cve	
				150.66 (0.37)	5.903 (0.029)	10	Pal	
18258+1952	BRT2446	AB	0.5533	321.32 (0.29)	3.330 (0.063)	48	Cve	N
				321.34 (0.23)	3.284 (0.103)	13	Pal	
18258+1952	BRT2446	AC	0.5533	254.82 (0.21)	8.010 (0.024)	43	Cve	N
				254.85 (0.25)	8.007 (0.027)	13	Pal	
18267+3211	ES 2418		0.5534	68.26 (0.29)	5.470 (0.020)	44	Cve	
				68.19 (0.21)	5.479 (0.020)	10	Pal	
18362+2437	POU3437		0.5506	284.22 (1.00)	4.932 (0.056)	38	Cve	
				283.94 (1.06)	4.872 (0.144)	11	Pal	
18370+2358	POU3440		0.5507	105.22 (0.90)	6.421 (0.056)	45	Cve	
				105.22 (0.48)	6.424 (0.065)	12	Pal	

Table 1. Continued

WDS	Disc.	Mult.	Epoch 2009+	$\theta[^\circ]$ (σ_θ)	ρ $['']$ (σ_ρ)	n	Auth.	Notes
18422+0917	BRT2179		0.5534	251.90 (0.21)	5.180 (0.033)	43	Cve	
				251.92 (0.17)	5.165 (0.030)	10	Pal	
18441+2500	POU3514		0.5507	273.36 (0.35)	6.769 (0.067)	48	Cve	
				273.30 (0.36)	6.727 (0.066)	12	Pal	
18471–0939	J 106	AC	0.5534	332.25 (0.59)	4.129 (0.172)	50	Cve	N
				333.23 (0.58)	4.041 (0.151)	10	Pal	
18503+1228	J 468		0.5534	140.88 (0.28)	9.504 (0.121)	47	Cve	N
19050+2114	HDS2708		0.5535	3.01 (0.17)	5.870 (0.053)	44	Cve	
				2.85 (0.21)	5.838 (0.076)	9	Pal	
19168+0141	BAL1515		0.5507	166.47 (0.49)	4.455 (0.057)	45	Cve	
				166.63 (0.51)	4.457 (0.054)	11	Pal	
19206–0740	LDS 678	AB	0.5508	306.98 (0.32)	26.773 (0.085)	18	Cve	
				306.01 (0.34)	26.825 (0.092)	9	Pal	
19206–0740	WRH 31	BC	0.5508	85.24 (0.88)	4.069 (0.138)	58	Cve	
				85.48 (0.57)	4.039 (0.165)	10	Pal	
19206–0740	LMP 41	BD	0.5508	320.09 (0.25)	20.273 (0.140)	10	Cve	
				318.57 (1.35)	20.244 (0.289)	9	Pal	
19287+1718	STE 1		0.5535	239.79 (0.22)	5.898 (0.017)	50	Cve	
				239.85 (0.10)	5.895 (0.017)	10	Pal	
19289+3515	POP 34	AB	0.5535	6.12 (0.13)	6.056 (0.031)	48	Cve	
				6.09 (0.14)	6.057 (0.018)	10	Pal	
19289+3515	POP 34	AC	0.5535	360.26 (0.07)	37.056 (0.051)	20	Cve	
				359.45 (0.06)	37.053 (0.053)	10	Pal	
19311+0821	OLE 3		0.5508	66.42 (0.49)	4.133 (0.140)	48	Cve	
				66.40 (0.91)	4.048 (0.167)	11	Pal	
19435+1056	BRT2183		0.5508	199.91 (2.84)	2.058 (0.244)	52	Cve	
				201.57 (1.83)	2.122 (0.257)	10	Pal	
19466+1024	J 150		0.5508	10.88 (3.85)	1.524 (0.134)	19	Cve	N
19500+0637	J 1336	AB	0.5535	57.73 (0.26)	5.421 (0.033)	34	Cve	
				57.67 (0.32)	5.397 (0.034)	10	Pal	
19500+0637	J 1336	AC	0.5535	219.96 (0.10)	23.538 (0.048)	30	Cve	
				220.00 (0.11)	23.540 (0.060)	10	Pal	

Table 1. Continued

WDS	Disc.	Mult.	Epoch 2009+	$\theta[°]$ (σ_θ)	ρ $['']$ (σ_ρ)	n	Auth.	Notes
19511+3443	OLE 2		0.5535	309.18 (0.44)	3.954 (0.029)	49	Cve	
				309.20 (0.36)	3.904 (0.058)	10	Pal	
20210+1028	J 838		0.5536	117.34 (0.23)	6.342 (0.022)	50	Cve	O
				117.21 (0.30)	6.344 (0.017)	10	Pal	

Table 2. Notes

WDS	Mult.	Notes
16284+3112		since $m_A = 11.4$ and $m_B = 11.5$, a quadrant change is possible
16469+0210		since $m_A = m_B = 10.8$, a quadrant change is possible
16507+1259		since $m_A = m_B = 11.5$, a quadrant change is possible
17222+3010		since $m_A = m_B = 10.98$, a quadrant change is possible
18258+1952	AB	since $m_A = 11.1$ and $m_B = 11.2$, a quadrant change is possible
18258+1952	AC	first measurement
18471–0939	AC	pair AB was not visually separated
18503+1228		there are only 3 measurements between 1911 and 1955, thus a misidentification is possible
19466+1024		since $m_A = 10.77$, $m_B = 11.0$ and components are close, measurements were difficult
20210+1028		Residual (O–C) from orbit Ole2002b (Olević 2002): (Cve) $+0\overset{\circ}{.}6$, $+0\overset{''}{.}185$; (Pal) $+0\overset{\circ}{.}5$, $+0\overset{''}{.}187$

components are outside the frame. We measured a new pair, WDS 18258+1952 = BRT 2446 AC. This system seems to be a multiple star rather than a double star.

The frames were measured by using AIP4WIN (version 1.4.21).

A total of 35 pairs was measured; where the orbit had been previously calculated (Olević 2002) for one of them, WDS 20210+1028 = J 838, and the orbital elements were given in the Sixth Catalog of Orbits of Visual Binary Stars[1]. In this case the measurements are compared to the ephemerides. For this pair the residuals are small. The apparent orbit for J 838 is presented in Fig. 1. The empty circles denote the micrometric measurements, the interferometric one is denoted by a filled circle, whereas our measurement is denoted by an asterisk.

The results for the position angle and separation are given in Table 1, the notes in Table 2. In Table 1, the individual results of the measurements of position angle and separation for each author are given. The designations used: WDS - identification in the Washington Double Star Catalog[2]; Disc. - double-star name after the discoverer; Mult. - des-

[1] http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/wds/orb6

[2] http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/wds/WDS

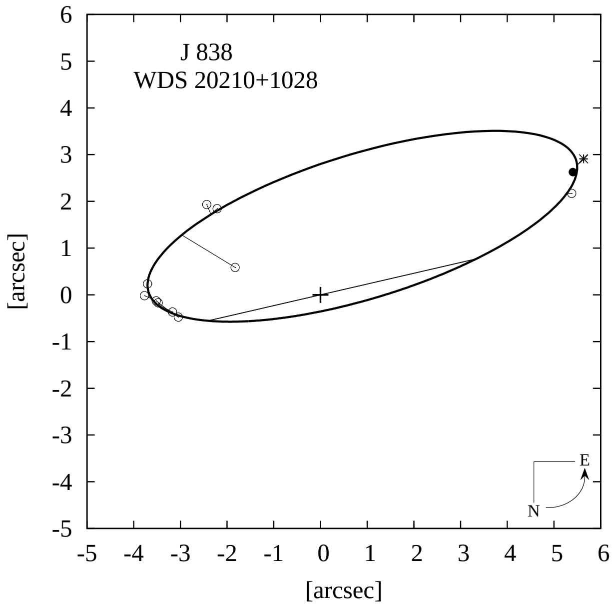

Fig. 1. *Apparent orbit for WDS 20210+1028 = J 838; our measurement is designated by an asterisk.*

ignation for pair components; Epoch - observational epoch; θ [°] (σ_θ) - position angle in degrees (error of the position angle) ; ρ [$''$] (σ_ρ) - separation in seconds of arc (error of the separation); n - number of measurements; Auth. - measurement author's name, Z. Cvetković (Cve) and R. Pavlović (Pal); Notes - means that there is a comment (N), or the pair has an orbit (O) in Table 2.

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CCD МЕРЕЊА ДВОЈНИХ И ВИШЕСТРУКИХ ЗВЕЗДА НА НАО РОЖЕН. IV

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Стручни чланак

Користећи двометарски телескоп бугарске Националне астрономске опсерваторије на Рожену снимили смо 30 двојних или вишеструких звезда у току две полуноћи 20. и 21. јула 2009. године. Ово је четврта серија мерења снимака двојних и вишеструких звезда добијених помоћу CCD камере на Рожену. У чланку дајемо резултате мерења позиционог угла и сепарације за 23 двојне и 5 вишеструких звезда (35 пара) које је било могуће измерити.