Results of 194 Double Stars Measurements from Astrometric CCD Observations at the Nikolaev Observatory (Ukraine)

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Abstract: This paper presents the results of double stars measurements from CCD observations at the 50-cm telescope of the Nikolaev Observatory. The accurate positions at current epoch and proper motions were obtained for 194 WDS pairs. The position angles and separations were measured using REDUC software. The measures standard errors were 0.05" for separations and 0.2° for position angles.

Instruments

These observations were carried out in Nikolaev Astronomical Observatory subordinated to Ministry of Education and Science of Ukraine. The observatory is located at an altitude of 52 m above sea level, the geographic coordinates are longitude 31° 58′ E, and latitude 46° 58′ N [1]. The observations were made at the mobile multi-channel automatic telescope (Mobitel, Figure 1), which was created in the RI NAO. The main telescope is a Maksutov telescope (D = 500 mm, F = 3000 mm), that is equipped with an Alta U9000 CCD camera from Apogee Imaging Systems. The CCD has a sensor array of 3056 by 3056 pixels, and each pixel is 12 microns square which allows us to obtain imaging with scale 0.83"/pixel and FOV = 42.6′×42.6′ in drift scan mode. That system enables us to obtain a sufficient number of reference stars for astrometric reduction in the UCAC4 catalog. For most stars the mean FWHM is less than 3".

Figure 1: The mobile multi-channel automatic telescope (Mobitel)

Program and Processing

For the observational program, we selected WDS catalog [2] objects which are most appropriate to be observed by our telescope in the expected time frame (the full time of exposure is 85 s at the equator). For the main selection criteria we used a magnitude limit of 17 and a separation bigger than two FWHM. We also measured other WDS doubles from the observation volume, which appeared in the imaged field.

All raw frames were processed using Astrometrica [3] software. The star positions were obtained using reference stars from UCAC4 catalog [4]. Equatorial coordinates were calculated for all objects in the field of view. The mean number of observations per star was about 8. The coordinates in right ascension and declination at mean observational epoch were averaged. Then we cross-matched our positional data with WDS catalog and other astronomical catalogs for calculating the primary and secondary components proper motions and

selecting all WDS doubles which appeared in the imaged field.

Measurement

The measurements of doubles were made with REDUC software [5]. For calibration, we used previously determined exact values of orientation angle and image inclination regarding the celestial equator from astrometric reductions. Position angle (Theta), separation (Rho), and their standard deviations were measured for each WDS double. The relationship between the standard error of the positional angle and separation measurements versus the separation are shown in Figure 2.

Summary of the measurements is presented in Table 1. The table data set also includes estimation of magnitude difference between components made by REDUC software, date of observation, and number of observations for each WDS object.

References

1. http://www.mao.nikolaev.ua/

2. Mason B.D. et al: 2001, Astron. J., 122, 3466

3. http://www.astrometrica.at/

4. Zacharias N. et al: 2013, Astron. J., 145, 44Z

5. http://www.astrosurf.com/hfosaf/index.htm

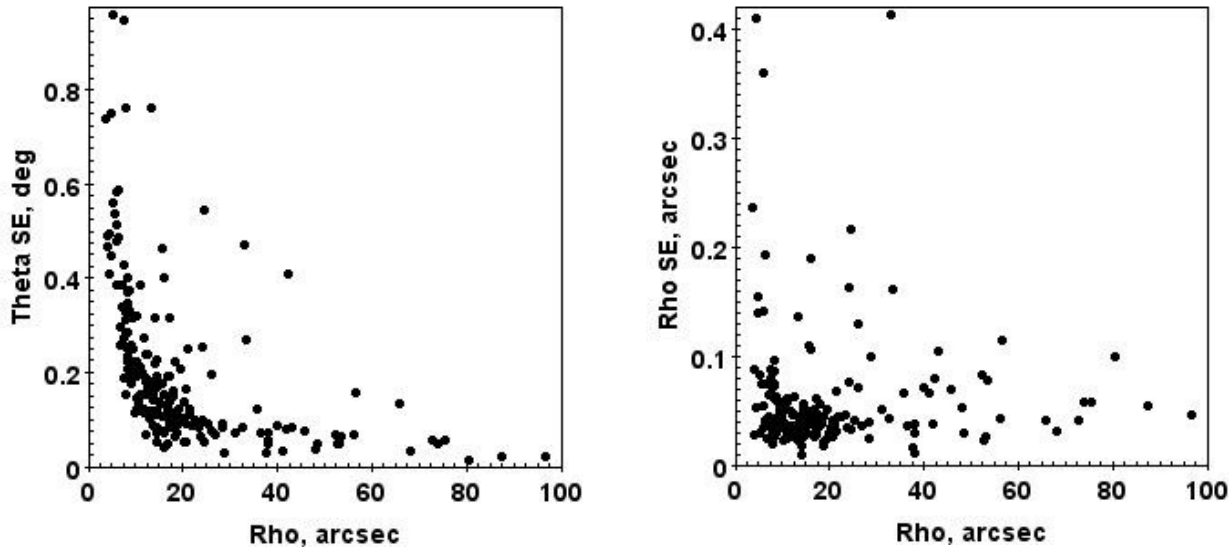

Figure 2. Standard errors in positional angle (left) and separation vs separation.

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Table 1. Results of measurements of the 194 doubles stars using REDUC software.

WDS no	Δ mag*	Theta	Std_Theta	Rho	Std_Rho	Y	M	D	N
00109+1705	5.82	98.1	1.5	13.46	0.27	2014	9	15	5
00146+2508	0.17	229.3	0.7	8.04	0.21	2014	10	11	9
00152+2454	1.38	159.6	0.2	31.27	0.15	2014	10	11	10
00197+1951	0.18	262.5	0.2	52.83	0.07	2014	10	9	10
00320+2509	1.32	228.9	0.2	38.10	0.12	2014	10	12	10
00374-0714	2.11	50.3	0.4	35.75	0.19	2014	10	11	9
00509+1215	2.82	95.6	1.1	24.36	0.43	2014	10	9	5
00541+1247	0.39	251.5	0.3	14.55	0.15	2014	10	1	10
00599+1400	2.54	158.5	0.2	45.74	0.21	2014	10	12	10
01116+0446	0.55	357.69	0.03	163.16	0.17	2014	10	6	8
01242+1254	0.03	217.1	0.1	28.58	0.30	2014	10	19	10
01493+1808	2.45	24.0	0.8	21.09	0.12	2014	10	14	10
01496+1741	4.17	343.9	0.2	24.30	0.13	2014	10	14	4
01598+1543	0.79	327.1	0.2	75.65	0.17	2014	10	19	10
02154+1126	0.98	162.7	0.3	43.19	0.31	2014	10	19	10
02476+1706	0.36	329.1	0.6	26.20	0.21	2014	10	19	10
02595+2440	0.59	210.5	0.4	13.73	0.12	2014	9	17	10
03134-0852	3.69	150.7	1.4	33.08	1.24	2014	10	19	10
03214+0803	1.01	84.5	1.2	4.31	1.23	2014	9	17	10
03216+0821	2.8	248.8	0.6	17.19	0.14	2014	9	17	10
03299+2417	3.48	13.5	0.2	26.17	0.37	2014	10	19	9
03308+2511	2.15	309.6	0.2	17.08	0.07	2014	9	19	5
03311+2437	1.55	50.5	0.1	14.47	0.08	2014	9	19	6
03308+2451	0.28	96.4	0.4	14.14	0.06	2014	9	19	5
03426+2430	0.59	344.5	2.2	3.54	0.71	2014	9	17	10
03435+2424	3.04	270.0	0.2	56.12	0.13	2014	9	17	10
03572-0706	2.13	104.4	0.2	65.73	0.06	2014	9	19	3
04026+1230	1.43	122.4	0.2	52.18	0.20	2014	9	14	7
04029+1228	1.25	339.7	0.2	39.78	0.18	2014	9	14	7
09225-0454	2.17	238.1	2.3	8.06	0.19	2014	3	18	10
09228-0516	3.37	309.9	0.3	33.64	0.22	2014	3	18	10
13040+2249	0.12	196.0	0.2	53.50	0.22	2014	3	21	9
13334+0636	1.92	78.2	0.1	165.13	0.22	2014	3	21	10
14491+0720	2.83	42.3	0.3	28.37	0.07	2013	4	29	10
16144+2740	0.04	39.7	0.2	38.08	0.03	2013	4	29	10
16244+3250	1.38	287.4	1.0	10.09	0.17	2013	5	25	10
16255+1944	0.14	339.8	0.5	7.87	0.09	2013	6	11	10
17018+1746	0.24	106.8	0.1	117.23	0.08	2013	5	27	10
17037+1336	0.0	116.55	0.01	304.94	0.03	2014	3	31	10
17126+1609	0.48	200.2	2.8	7.45	0.24	2013	6	19	10
17427+2459	0.08	123.9	1.5	6.44	0.12	2013	5	20	10
17512+2946	0.67	146.9	0.8	7.61	0.20	2013	7	11	10
17599+0435	0.41	359.7	0.2	26.98	0.11	2014	7	26	10

Table 1 continues on next page.

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Table 1 (continued). Results of measurements of the 194 doubles stars using REDUC software.

WDS no	Δ mag*	Theta	Std_Theta	Rho	Std_Rho	Y	M	D	N
18048+1253	0.56	277.1	0.4	18.62	0.13	2014	7	26	10
18057+1253	0.88	271.5	0.6	10.95	0.09	2014	7	26	10
18328+0633	1.05	58.3	0.6	12.16	0.09	2013	6	11	10
18331+0649	0.24	342.7	1.0	7.76	0.06	2013	6	11	10
18490+2405	0.81	273.4	1.0	9.58	0.15	2013	6	11	10
18491+2405	1.31	255.6	1.0	8.76	0.19	2013	6	11	10
18493+2411	0.9	106.5	1.3	7.47	0.26	2013	6	11	10
18499+2403	0.26	176.0	0.3	15.46	0.11	2013	6	11	9
18502+2414	0.88	169.5	0.5	8.90	0.11	2013	6	11	10
19328+1219	0.62	31.4	0.2	41.92	0.11	2013	7	9	10
19329+1223	1.54	148.7	0.1	112.96	0.14	2013	7	9	10
19332+1241	0.93	58.60	0.03	293.43	0.09	2013	7	9	10
19333+1248	0.49	193.9	0.1	37.64	0.05	2013	7	9	10
19338+1247	0.38	4.90	0.04	87.30	0.11	2013	7	9	5
19461+0131	0.51	257.1	0.4	10.38	0.07	2013	7	9	10
19503+1148	1.19	68.3	0.1	73.84	0.17	2013	6	11	10
19511+1140	1.34	237.84	0.04	140.99	0.12	2013	6	11	10
19568+2516	1.94	322.3	0.3	10.84	0.13	2013	6	19	6
20029+1328	0.36	56.56	0.02	80.40	0.14	2013	6	19	3
20030+1328	0.48	169.7	0.2	56.61	0.16	2013	6	19	3
20033+1354	0.82	40.31	0.05	47.94	0.08	2013	6	19	3
20033+1347	2.02	140.85	0.03	117.17	0.05	2013	6	19	3
20221+0331	2.56	217.4	0.5	20.51	0.13	2013	6	11	10
20253+0355	1.51	87.0	0.3	20.53	0.08	2013	6	11	10
20305+2411	0.45	220.0	0.2	20.56	0.10	2013	6	11	10
20305+2358	1.31	140.9	0.4	19.05	0.07	2013	6	11	10
20306+2417	0.79	228.9	0.3	17.91	0.13	2013	6	11	10
20306+2406	0.16	59.3	0.1	16.16	0.12	2013	6	11	10
20308+2416	0.27	248.5	0.3	22.51	0.14	2013	6	11	10
20308+2404	1.26	227.0	0.9	8.33	0.29	2013	6	11	10
20311+2429	0.15	281.8	0.4	13.17	0.11	2013	6	11	10
20313+2406	0.97	245.3	0.3	11.81	0.11	2013	6	11	6
20359+2331	0.87	292.8	0.4	17.90	0.10	2014	9	19	8
20359+2327	1.07	152.1	0.6	18.42	0.11	2014	9	19	8
20365+2334	2.35	56.6	0.2	18.28	0.10	2014	9	19	8
20365+2327	1.04	226.6	0.3	17.10	0.08	2014	9	19	8
20366+2342	0.25	22.5	0.8	6.75	0.20	2014	9	19	8
20367+2328	1.6	24.9	0.3	19.9	0.08	2014	9	19	8
20367+2327	0.61	300.7	0.6	8.23	0.20	2014	9	19	8
20367+2319	1.12	240.6	2.7	5.27	0.24	2014	9	19	9
20367+2316	2.48	331.8	0.8	7.87	0.09	2014	9	19	9
20368+2324	1.02	76.3	0.4	15.01	0.12	2014	9	19	9
20369+2330	0.93	326.3	0.3	17.29	0.16	2014	9	19	8
20369+2325	1.69	268.2	0.5	17.94	0.12	2014	9	19	9
20363+2321	0.82	134.1	0.3	21.57	0.19	2014	9	19	9

Table 1 continues on next page.

Table 1 (continued). Results of measurements of the 194 doubles stars using REDUC software.

WDS no	Δ mag*	Theta	Std_Theta	Rho	Std_Rho	Y	M	D	N
20397+1415	0.97	147.1	0.3	32.54	0.13	2013	6	11	10
20397+1406	1.57	285.6	1.8	6.46	0.58	2013	6	11	10
20401+2509	2.07	288.9	0.4	10.36	0.11	2014	8	30	10
20401+2458	0.34	24.1	1.1	16.11	0.30	2014	8	30	9
20401+2450	0.4	34.5	1.6	5.63	0.22	2014	8	30	10
20412+2448	1.54	139.2	0.2	15.47	0.13	2014	8	30	10
20415+2459	1.42	197.7	0.6	8.83	0.10	2014	8	30	10
20417+2449	0.72	35.7	0.7	8.40	0.10	2014	8	30	9
20417+2437	2.99	94.1	0.6	8.37	0.10	2014	8	30	8
20401+2516	0.51	339.6	0.3	21.87	0.13	2014	9	17	10
20401+2513	1.1	296.1	0.2	18.58	0.05	2014	9	17	10
20408+2521	1.54	232.6	0.4	16.89	0.13	2014	9	17	10
20408+2505	3.2	302.7	0.3	18.68	0.06	2014	9	17	10
20413+2513	2.06	244.9	0.5	13.26	0.13	2014	9	17	10
20478+1109	0.64	58.3	0.2	48.63	0.09	2013	8	8	10
20487+2517	1.31	78.3	0.7	14.63	0.13	2014	8	20	10
20491+2509	0.09	101.1	0.6	8.81	0.18	2014	8	20	10
20492+2504	0.78	68.2	1.5	3.93	0.08	2014	8	20	10
20492+2510	1.2	355.6	1.8	5.98	0.10	2014	8	20	10
20495+2516	1.38	80.2	1.0	8.58	0.09	2014	8	20	10
20497+2507	1.42	276.1	0.8	9.61	0.16	2014	8	20	10
20497+2526	0.1	336.3	0.3	14.64	0.10	2014	8	20	10
20499+2454	0.41	53.8	0.7	9.69	0.14	2014	8	20	10
20499+2456	1.04	235.2	1.1	8.27	0.22	2014	8	20	10
20499+2508	0.22	341.7	1.5	4.55	0.16	2014	8	20	10
20499+2510	1.49	19.5	0.2	12.23	0.14	2014	8	20	10
20500+2508	0.89	253.9	0.7	12.48	0.19	2014	8	20	10
20501+2512	3.11	341.6	0.5	16.14	0.13	2014	8	20	10
20503+2507	2.78	83.9	0.4	10.72	0.10	2014	8	20	10
20543+2441	0.99	201.8	0.7	9.14	0.14	2014	9	2	11
20573+1434	0.68	60.9	0.2	72.94	0.12	2014	9	19	9
20580+1426	0.58	339.3	0.2	14.31	0.12	2014	9	19	10
21017+2516	0.59	167.3	0.8	6.79	0.07	2014	9	17	10
21024+2518	0.54	124.5	0.3	21.44	0.09	2014	9	17	10
21026+2515	0.47	353.4	0.4	16.86	0.15	2014	9	17	10
21027+2508	0.58	25.4	0.6	10.04	0.12	2014	9	17	10
21020+2515	0.83	312.0	0.2	18.30	0.12	2014	9	17	10
21057+2412	0.17	245.9	0.1	16.03	0.27	2014	8	30	3
21060+1443	0.34	137.3	0.1	68.31	0.08	2013	11	1	8
21060+2406	3.08	188.2	0.6	11.00	0.08	2014	8	30	10
21062+2346	0.51	76.4	0.4	15.19	0.09	2014	8	30	10
21065+2332	0.02	190.3	2.3	4.89	0.46	2014	8	30	10
21066+2347	2.17	223.1	0.4	20.09	0.09	2014	8	30	10
21068+2400	0.08	169.0	0.7	12.25	0.14	2014	8	30	10
21069+0458	4.61	271.4	0.1	53.01	0.08	2013	8	8	10

Table 1 continues on next page.

Table 1 (continued). Results of measurements of the 194 doubles stars using REDUC software.

WDS no	Δ mag*	Theta	Std_Theta	Rho	Std_Rho	Y	M	D	N
21070+1500	0.42	317.4	0.1	38.13	0.08	2013	11	1	8
21071+2332	0.29	86.1	0.4	11.48	0.08	2014	8	30	10
21101+2516	1.77	249.9	0.5	12.14	0.10	2014	8	20	10
21104+2512	0.75	247.0	1.7	5.38	0.09	2014	8	20	10
21105+2452	1.0	190.8	1.4	6.17	0.17	2014	8	20	10
21107+2512	0.36	138.9	0.5	13.93	0.14	2014	8	20	10
21108+2445	2.44	58.7	0.4	14.52	0.10	2014	8	20	10
21108+2452	0.63	145.0	1.0	8.11	0.08	2014	8	20	10
21110+2448	0.59	84.5	0.8	11.83	0.10	2014	8	20	10
21110+2519	2.13	194.0	0.3	13.83	0.06	2014	8	20	10
21185+2454	1.99	31.9	0.8	9.13	0.12	2014	8	28	10
21189+2504	1.24	166.3	0.2	16.87	0.11	2014	8	28	10
21194+2513	0.12	53.7	0.6	9.87	0.11	2014	8	28	9
21198+2435	0.81	85.2	1.2	5.85	0.32	2014	8	28	6
21200+2440	1.04	267.3	0.6	11.44	0.09	2014	8	28	9
21223+1111	0.9	191.1	1.3	4.16	0.25	2014	10	12	9
21227+1101	1.45	336.1	0.1	96.62	0.14	2014	10	12	10
21229+2346	0.09	192.2	0.4	13.84	0.13	2014	9	17	10
21240+2352	0.61	240.7	1.2	7.16	0.19	2014	9	17	10
21233+2401	1.02	49.3	0.5	12.71	0.08	2014	9	17	10
21282+1519	2.32	174.2	0.6	11.11	0.18	2013	8	8	10
21314+2451	2.68	127.0	0.4	17.23	0.12	2014	8	10	8
21315+2503	1.25	18.4	1.1	8.83	0.09	2014	8	20	10
21326+2522	1.11	66.4	0.2	36.63	0.11	2014	8	20	10
21329+2509	2.35	192.0	0.6	14.57	0.08	2014	8	20	10
21447+2402	1.99	298.4	0.8	7.06	0.10	2014	9	17	6
21462+2353**	0.23	128.6	0.8	8.13	0.19	2014	9	17	6
21462+2353**	0.99	212.2	0.5	19.65	0.11	2014	9	17	6
21455+2349	0.11	39.4	0.3	12.76	0.07	2014	9	17	10
21449+1040	0.22	55.0	0.9	7.89	0.09	2014	8	30	9
21528+2458	0.09	178.3	0.7	10.38	0.16	2014	8	20	10
21529+2525	0.03	11.9	0.3	23.47	0.14	2014	8	20	10
21534+2447	1.26	100.1	0.3	9.91	0.12	2014	8	20	10
21536+2516	1.57	322.9	0.3	18.07	0.17	2014	8	20	10
21539+2446	1.17	359.9	0.5	15.52	0.15	2014	8	20	10
21545+1615	1.49	20.2	1.1	8.44	0.11	2013	8	8	9
22010+2439	2.14	19.9	0.6	14.15	0.05	2014	8	28	10
22010+2453	0.09	178.8	0.5	12.25	0.14	2014	8	28	10
22016+2421	0.59	135.9	0.9	7.78	0.12	2014	8	28	10
22017+2446	0.85	78.0	0.5	13.82	0.11	2014	8	28	10
22021+2422	0.64	255.5	1.3	4.82	0.42	2014	8	28	10
22024+2420	0.7	65.0	0.5	7.40	0.10	2014	8	28	9
22138+2408	2.03	248.3	0.5	14.51	0.17	2014	8	20	10
22146+2342	0.2	28.5	0.4	16.94	0.08	2014	8	20	10
22312+0253	1.24	168.0	0.2	20.44	0.10	2014	8	30	10

Table 1 concludes on next page.

Table 1 (conclusion). Results of measurements of the 194 doubles stars using REDUC software.

WDS no	Δ mag*	Theta	Std_Theta	Rho	Std_Rho	Y	M	D	N
22335+1519	0.48	263.0	1.2	42.30	0.24	2014	10	19	10
22351+0346	2.1	289.31	0.04	369.81	0.13	2014	8	20	9
22428+2947	1.06	276.6	0.3	25.45	0.12	2014	8	28	10
22429+2958	0.79	52.4	0.3	28.49	0.12	2014	8	28	10
22430+2944	0.43	124.3	0.5	13.63	0.13	2014	8	28	10
22432+2941	0.63	283.9	0.5	18.06	0.11	2014	8	28	10
22439+2938	0.07	227.7	0.7	9.12	0.13	2014	8	28	10
22441+2940	1.46	149.9	0.2	23.85	0.10	2014	8	28	10
22443+2957	0.27	218.5	0.2	24.58	0.10	2014	8	28	10
22481+2444	0.74	38.9	0.1	41.25	0.15	2014	9	17	6
22482+2434	0.08	195.7	0.4	11.84	0.08	2014	9	17	10
22578+1833	0.62	80.8	0.5	16.85	0.08	2014	10	14	8
22574+1827	0.11	183.9	0.1	111.56	0.09	2014	10	14	9
23232-0839	2.02	94.4	0.7	157.30	0.13	2014	10	19	10
23527-0328	3.47	1.6	0.7	6.04	0.62	2014	10	14	4
23523-0341	1.9	178.6	0.1	277.12	0.10	2014	10	14	10
23533+0208	0.23	1.2	0.8	15.64	0.19	2013	11	1	4

Notes:

* all observations were obtained with filter close to R_c band;

** this star is triple and has two records in WDS; we measured both in the same order as in the catalog.