Revista Mexicana de Astronomía y Astrofísica, **46**, 245–251 (2010)

SPECKLE INTERFEROMETRY AT THE OBSERVATORIO ASTRONÓMICO NACIONAL. II

V. G. Orlov, V. V. Voitsekhovich, J. L. Rivera, C. A. Guerrero, and F. Ortiz

Instituto de Astronomía, Universidad Nacional Autónoma de México, Mexico

Received 2010 March 27; accepted 2010 May 27

RESUMEN

Presentamos mediciones interferométricas de motas para estrellas binarias, obtenidas en junio de 2009 en el telescopio de 1.5 m del Observatorio Astronómico Nacional en San Pedro Mártir (México). Nuestros datos comprenden 189 mediciones de ángulos de posición y separaciones de 144 sistemas. Las separaciones angulares medidas abarcan desde $0''.16$ hasta $3''.64$. La magnitud máxima de la componente más brillante es de 10.96. El error medio en las separaciones es de $0''.02$ y en los ángulos de posición de 1.5°. Algunos ángulos de posición se determinaron con la ambigüedad usual de 180°.

ABSTRACT

We present speckle interferometric measurements of binary stars made during June of 2009 with the 1.5 m telescope of the Observatorio Astronómico Nacional at SPM (Mexico). The data contain 189 position angle and separation measures of 144 systems. The measured angular separations range from $0''.16$ to $3''.64$. The maximum magnitude of the brighter component is 10.96. The mean error in separation is $0''.02$ and in the position angles 1.5°. Some of the position angles were determined with the usual 180° ambiguity.

Key Words: binaries: visual — stars: fundamental parameters — techniques: high angular resolution — techniques: interferometric

1. INTRODUCTION

In our previous paper (Orlov et al. 2009) we reported results of speckle observations of binary stars obtained at the 1 m telescope of Observatorio Astronómico Nacional at Tonanzintla (OAN-Tonanzintla), Mexico. The telescope is located at a site with moderate seeing. As it is well known the resolution of speckle interferometry (SI) does not depend on seeing. However, the limiting magnitude of stars which can be resolved by SI does depend on seeing. The Instituto de Astronomía has a total of four telescopes. Three of them are situated at Observatorio Astronómico Nacional at San Pedro Mártir, Mexico (OAN-SPM). The OAN-SPM is located in one of the best astronomical sites (Ávila, Cruz-González, & Tapia 2003). Included at the SPM site are 3 telescopes: 84 cm, 1.5 m and 2.1 m.

In this paper we present results from four observing nights in June 2009. The observations were performed at the 1.5 m telescope of the OAN-SPM.

2. OBSERVATIONS

The observations were performed at the 1.5 m telescope of the Observatorio Astronómico Nacional which is located at the San Pedro Mártir (Mexico). For these observations we used the DRAGON equipment (Voitsekhovich et al. 2005), which was slightly modified to be able to record speckle interferograms (Orlov et al. 2007). During the observations we had good seeing conditions. We estimated that the seeing was between 0.7 to 1 arcsec. Unfortunately, aberrations introduced by the telescope had a larger effect. It can be clearly seen on a centered image of one of the stars (Figure 1). Aberrations of the 1.5 m mirror cannot be corrected because the telescope is not equipped with an active optics system.

After calibration we determine the Pixel Scale = $0.024''$/px and detector orientation. For calibration we used 40 wide pairs with very slow orbital motions and some of them with known orbital parameters.

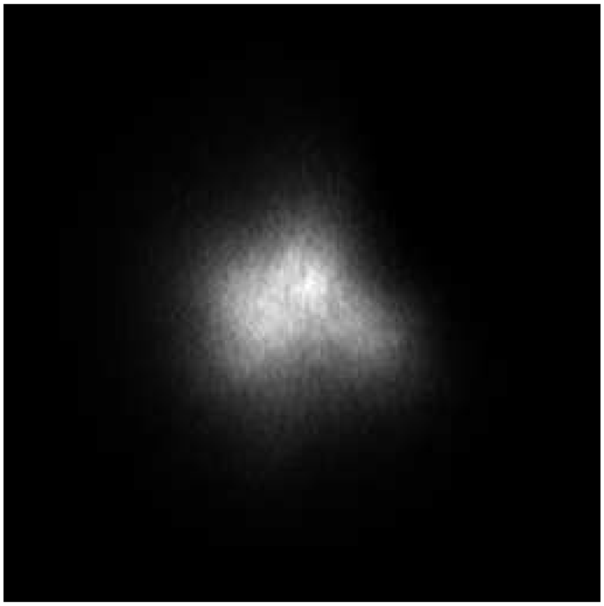

Fig. 1. The centered image of the binary star COU 1581. It was obtained by averaging 700 previously centered speckle interferograms. The window is $6''.3 \times 6''.3$.

During four nights of observations we made 189 measurements of 144 pairs. Most of observed binaries have separations less than $1''$. Table 1 shows how these 144 pairs are distributed according to their separations.

3. DATA PROCESSING AND RESULTS

For each binary star, a typical observing procedure involved the accumulation of one set of 700 short exposure images on hard disk. One short exposure image consists of a two-dimensional 582×584 array of 8-bit numbers. The volume of one set on the hard disk is 226 MB. The data were processed by the algorithm which was explained in detail by Tokovinin, Mason, & Hartkopf (2010). This algorithm permits derivation of the binary star parameters without using the reference star. The resulting autocorrelation function (ACF) of one binary star COU 1581 calculated by this algorithm is shown in Figure 2. The position of the secondary is calculated as the center of weight of values of the ACF in a region around the maximum value.

TABLE 1

DISTRIBUTION OF PAIRS BY THEIR SEPARATIONS

$> 1''.5$	$1''.5 - 1''$	$1'' - 0''.5$	$0''.5 - 0''.25$	$< 0''.25$
18	23	38	57	12

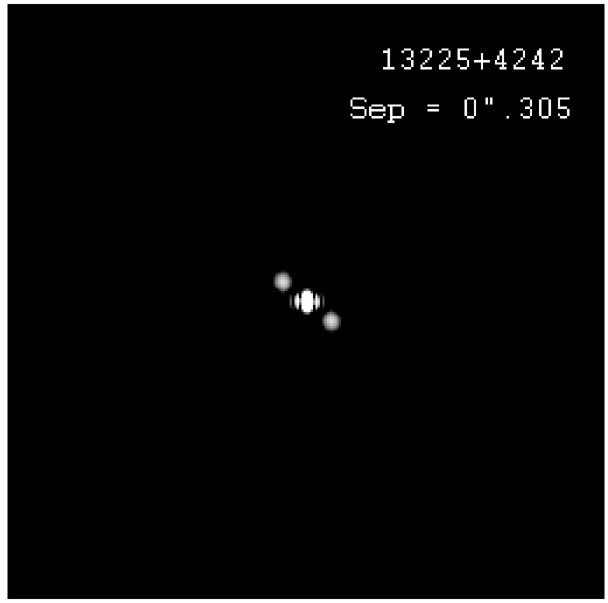

Fig. 2. Reconstructed ACF of the binary star COU 1581. Separation = $0''.305$.

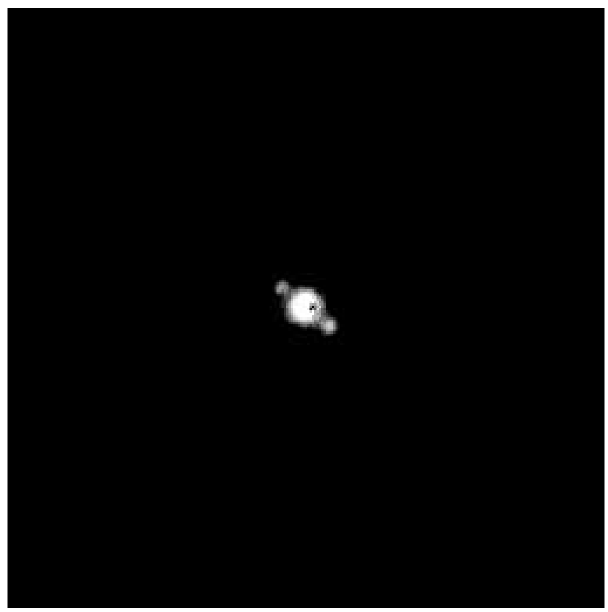

Fig. 3. Result of self-calibrating shift-and-add technique for the binary star COU 1581.

As is well known, the ACF has no information about the Fourier phase of the image; therefore, the position angle is determined only modulo 180°. To avoid this inconvenience we also used Christou's self-calibrating shift-and-add technique (Christou et al. 1986). Figure 3 shows an image which was calculated using this technique. We have to admit that the

TABLE 2

SPECKLE MEASUREMENTS ON THE 1.5 M TELESCOPE

WDS ($\alpha, \delta J2000.0$)	Disc. Name	Date Besselian	P.A (deg)	Sep. (arcsec)	P.A. Orb. (deg)	Sep. Orb. (arcsec)	Reference
12154+4008	A 1999	2009.4326	62.2	0.29	40.9	0.53	Seymour et al. 2002
12182+2718	HDS1733	2009.4410	241.9	0.32			
12244+4305	STT 250	2009.4327	351.2	0.33			
12306+3431	HDS1759	2009.4327	203.3	0.27			
12328+2301	AG 179	2009.4327	142.0	0.99			
12510+3129	HDS1804	2009.4300	256.8	0.75			
12510+3129	HDS1804	2009.4327	257.2	0.75			
12575+2457	COU 397	2009.4300	60.6	0.68			
12575+2457	COU 397	2009.4410	60.6	0.68			
12575+2457	COU 397	2009.4327	61.1	0.69			
13004+3545	HU 1141	2009.4327	343.5	0.49			
13037+2339	STF1714	2009.4410	307.2	3.12			
13037+2339	STF1714	2009.4327	307.2	3.13			
13063+2044	HU 739	2009.4327	204.1	1.37	207.3	1.39	Seymour et al. 2002
13063+2044	HU 739	2009.4410	204.1	1.37			
13091+2127	HU 572	2009.4411	344.6	0.46	10.1	0.35	Zulevic 1969
					105.5	0.52	Baize 1981
					50.7	0.35	Baize 1986
13128+4030	A 1606	2009.4328	195.9	1.29			
13128+4030	A 1606	2009.4411	196.5	1.30			
13221+3952	HDS1876	2009.4300	88.9	0.26			
13225+4242	COU1581	2009.4411	157.5	0.33			
13266+3235	COU 787	2009.4300	147.4	0.34			
13280+3235	A 1856	2009.4411	343.5	1.08			
13280+3235	A 1856	2009.4328	343.7	1.07			
13305+3430	A 1857	2009.4301	340.9	0.48			
13305+3430	A 1857	2009.4328	341.4	0.47			
13348+4242	HDS1908	2009.4411	24.1	0.48			
13387+3823	COU1429AB	2009.4411	64.0	0.66			
13387+3823	COU1429AB	2009.4301	64.4	0.66			
13465+1545	A 2063	2009.4411	136.9	0.23			
13465+1545	A 2063	2009.4328	136.9	0.19			
13465+1545	A 2063	2009.4301	137.4	0.25			
13509+3555	COU1132	2009.4301	147.5	0.79			
13509+4422	A 1613AB	2009.4328	259.9	3.08			
13571+3426	BU 937	2009.4301	135.0	1.04			
14082+3645	STT 276AB	2009.4301	206.9	0.44			
14087+3341	HU 742	2009.4329	354.0	0.24	67.0	0.29	Popovic 1972
14087+3341	HU 742	2009.4412	355.6	0.25			
14109+1513	HDS1989Aa,Ab	2009.4412	358.7	0.43			
14109+2412	HDS1988	2009.4329	150.2	3.29			
14113+3013	COU 605	2009.4412	163.5	0.26			
14113+3013	COU 605	2009.4329	164.4	0.27			
14124+2843	STT 277AB	2009.4301	64.3	0.19			
14164+2539	HDS2006	2009.4412	249.2	0.70			
14184+3412	HU 901	2009.4301	32.6	0.61			
14276+2037	HO 542	2009.4329	213.6	0.98			
14278+3257	STF1848	2009.4302	356.2	3.09			
14278+3257	STF1848	2009.4412	356.3	3.08			
14295+3612	HU 1268	2009.4412	345.2	0.30	313.0	0.38	Erceg 1975
14436+3745	STF1875	2009.4329	128.5	3.06			
14485+2445	COU 304	2009.4329	300.8	0.46			

TABLE 2 (CONTINUED)

WDS ($\alpha, \delta J2000.0$)	Disc. Name	Date Besselian	P.A (deg)	Sep. (arcsec)	P.A. Orb. (deg)	Sep. Orb. (arcsec)	Reference
15002+2129	HU 907	2009.4413	277.3	0.24			
15002+2129	HU 907	2009.4329	278.0	0.21			
15049+3428	STF1908AB	2009.4413	151.4	1.33			
15075+1541	A 2228	2009.4330	12.2	3.29			
15136+3453	HO 60	2009.4413	68.1	0.18	72.7	0.16	Baize 1993a
15136+3453	HO 60	2009.4330	73.5	0.16	72.7	0.16	Baize 1994
15151+3650	STT 295	2009.4413	150.3	0.30			
15192+4329	A 1630	2009.4330	244.8	0.78			
15208+4242	A 573	2009.4413	171.9	0.71			
15257+2638	STF1941	2009.4330	212.6	1.38			
15271+2355	A 82	2009.4330	351.0	0.83			
15272+4133	COU1443	2009.4413	172.8	0.49			
15307+3810	HU 1163	2009.4413	168.1	0.22	189.1	0.17	Couteau 1990
15307+3810	HU 1163	2009.4330	169.3	0.21	191.9	0.21	Zulevic 1995
					191.9	0.21	Zulevic 1996
					169.4	0.21	Hartkopf et al. 2000
15390+2545	COU 612	2009.4413	177.5	0.29	326.6	0.15	Baize 1992a
					326.6	0.15	Baize 1993b
					176.2	0.26	Docobo & Ling 1998a
					173.2	0.30	Aristidi et al. 1999
15404+2123	HU 579	2009.4414	136.5	0.70			
15498+4431	BU 621	2009.4302	26.4	0.67			
15554+2932	HO 399	2009.4302	117.3	3.59			
15574+4140	STF1991AB	2009.4331	195.5	3.02			
15574+4140	STF1991AB	2009.4414	195.8	3.01			
15574+4140	STF1991AB	2009.4302	196.4	2.99			
16115+1507	A 1799	2009.4414	117.6	0.76			
16128+3922	STF2028	2009.4302	144.7	0.39	140.8	0.33	Alzner 2001
16156+1944	HU 480	2009.4331	261.9	1.61			
16161+2936	A 348	2009.4302	149.2	1.04			
16192+4140	STT 309	2009.4302	307.4	0.28	306.6	0.28	Seymour et al. 2002
16199+2341	COU 108	2009.4414	255.1	0.63			
16199+2341	COU 108	2009.4331	255.9	0.62			
16248+3925	HU 1276	2009.4302	270.3	0.39			
16248+3925	HU 1276	2009.4414	270.4	0.42			
16273+2653	A 226	2009.4331	94.1	1.01			
16273+2653	A 226	2009.4415	94.3	1.02			
16309+3804	STF2059	2009.4303	186.3	0.36			
16326+2314	BU 817	2009.4303	327.9	0.94			
16326+2314	BU 817	2009.4331	328.1	0.94			
16384+3514	COU 985	2009.4415	69.4	0.30	79.4	0.20	Baize 1993c
16384+3514	COU 985	2009.4331	70.1	0.30	82.8	0.21	Docobo & Ling 1998b
					82.8	0.20	Docobo et al. 2000
16412+1714	HDS2366	2009.4331	95.8	0.53			
16422+3753	HDS2372	2009.4303	252.1	0.18			
16422+4112	STF2091	2009.4303	325.9	0.40			
16476+4255	COU1452	2009.4415	103.5	0.26			
16476+4255	COU1452	2009.4332	108.6	0.29			
16539+2547	COU 492	2009.4332	91.9	0.52			
16539+2547	COU 492	2009.4415	91.9	0.52			
17063+2631	A 228	2009.4388	185.7	0.46			
17075+3810	COU1291	2009.4303	301.1	0.28	0.6	0.15	Baize 1993c
					356.3	0.07	Docobo & Ling 1998a
					348.0	0.07	Docobo & Ling 2002

TABLE 2 (CONTINUED)

WDS ($\alpha, \delta J2000.0$)	Disc. Name	Date Besselian	P.A (deg)	Sep. (arcsec)	P.A. Orb. (deg)	Sep. Orb. (arcsec)	Reference
17094+1901	A 2086	2009.4332	204.3	3.14			
17116+3916	HU 1178AB	2009.4332	9.5	0.36			
17116+3916	HU 1178AB	2009.4303	10.4	0.36			
17116+3916	HU 1178AB	2009.4303	10.7	0.36			
17184+3240	BU 628	2009.4303	267.1	0.52	255.4	0.39	Zulevic 1986
17215+2845	KUI 80AB	2009.4388	169.9	0.62			
17221+2310	COU 415	2009.4388	249.3	0.24	174.5	0.27	Baize 1992a
					174.5	0.27	Baize 1993b
17239+3627	STF2162	2009.4304	284.5	1.35			
17250+4306	COU1454	2009.4304	148.0	0.98			
17251+3444	HU 922	2009.4304	225.4	0.21	6.8	0.31	Heintz 1982
17275+1627	A 2184	2009.4388	30.4	1.87			
17377+4250	HDS2489	2009.4304	346.7	0.55			
17377+4250	HDS2489	2009.4332	347.1	0.55			
17412+4139	STF2203	2009.4416	293.7	0.73			
17434+3357	HO 560	2009.4304	263.3	1.32			
17434+3357	HO 560	2009.4416	263.3	1.33			
17434+3357	HO 560	2009.4388	265.2	1.37			
17486+2339	BAR 8	2009.4416	237.8	1.16			
17504+3526*	STF2236	2009.4389	18.9	0.31			
17504+3526*	STF2236	2009.4304	22.6	0.32			
17504+3526	STF2236	2009.4389	97.0	3.39			
17504+3526	STF2236	2009.4304	97.1	3.37			
17506+3932	COU1301	2009.4389	84.3	1.74			
17506+3932	COU1301	2009.4416	85.0	1.74			
17541+2949	AC 9	2009.4389	240.6	1.09			
17577+2815	HO 424	2009.4389	203.0	1.42			
17584+3524	COU1000	2009.4416	153.3	0.89			
17591+3228	HU 1185	2009.4416	138.5	0.36	148.4	0.27	Heintz 1975
18017+4011	STF2267	2009.4304	271.1	0.55			
18017+4011	STF2267	2009.4389	271.7	0.56			
18025+4414	BU 1127AB	2009.4332	52.9	0.73	65.4	1.15	Popovic 1970
					62.6	1.02	Popovic & Pavlovic 1995a
					62.6	1.02	Popovic & Pavlovic 1995b
18033+3921	STF2275	2009.4416	297.2	0.27	300.0	0.26	Popovic 1998
					299.9	0.26	Popovic et al. 2000
18063+3824	HU 1186	2009.4304	115.6	0.25	141.3	0.09	Heintz 1965
18063+3824	HU 1186	2009.4416	123.3	0.30	119.0	0.22	Baize 1992b
					121.1	0.20	Heintz 1995
18126+3836	BU 1091	2009.4305	320.7	0.72			
18126+3836	BU 1091	2009.4416	320.7	0.72			
18178+4351	A 578 AB	2009.4332	157.2	1.75			
18178+4351	A 578 Aa,Ab	2009.4332	247.0	0.31			
18264+4326	HDS2606	2009.4417	49.3	1.02			
18432+3822	HDS2651	2009.4305	50.8	0.44			
18450+4239	HDS2657	2009.4305	37.1	0.21			
19018+3448	COU1612	2009.4305	318.7	0.82			
19072+4451	A 703	2009.4305	188.4	0.54			
19072+4451	A 703	2009.4390	189.3	0.56			
19089+3404	COU1462	2009.4306	204.7	0.19	225.1	0.62	Mante 1994
					203.0	0.20	Mante 1997
					203.0	0.20	Mante 1999
19122+3215	HU 941	2009.4333	146.1	1.08			
19131+2154	A 153	2009.4306	267.7	0.71			

TABLE 2 (CONTINUED)

WDS ($\alpha, \delta J2000.0$)	Disc. Name	Date Besselian	P.A (deg)	Sep. (arcsec)	P.A. Orb. (deg)	Sep. Orb. (arcsec)	Reference
19214+1948	HO 637	2009.4333	27.6	1.20			
19251+2213	COU 513	2009.4333	2.6	0.25			
19266+3120	HDS2762	2009.4306	214.6	0.35			
19272+1626	HDS2765	2009.4333	177.5	0.36			
19331+3254	HU 948AB	2009.4306	149.9	0.26			
19331+3254	HU 948AB	2009.4333	152.2	0.27			
19350+2947	A 368	2009.4306	153.4	0.50			
19356+4002	A 1400	2009.4390	122.5	0.35	134.3	0.24	Seymour et al. 2002
19358+2316	A 163	2009.4333	20.8	0.23	1.7	0.18	Baize 1981
19466+4346	HDS2810	2009.4390	49.5	0.34			
19532+4238	COU2635	2009.4390	157.5	0.54			
19538+2237	COU 825AB	2009.4334	32.0	1.23			
19575+2018	BU 425AB	2009.4334	239.7	1.35			
19583+2208	AG 244AB	2009.4334	273.2	1.51			
20016+3435	COU1947	2009.4307	88.4	0.27			
20082+2105	J 1168	2009.4334	192.6	0.88			
20109+2237	HDS2877	2009.4334	201.4	0.45			
20157+4339	A 2095AB	2009.4390	155.9	0.26	146.7	0.21	Zulevic 1997
					146.8	0.24	Ling 1999
20157+4339	STF2659AC	2009.4390	314.0	3.03			
20172+2415	HDS2893	2009.4334	168.4	0.31			
20177+4030	HDS2897	2009.4390	269.0	0.33			
20302+2651	WOR 9AB	2009.4334	256.4	0.51			
20333+2727	HDS2935	2009.4334	114.1	0.48			
20477+4204	BU 268	2009.4391	199.3	0.39			
20506+3024	STT 415	2009.4280	232.2	3.68			
20531+2909	STT 417AB	2009.4280	27.7	0.90			
20564+4308	COU2544	2009.4391	160.4	0.32			
20564+4308	COU2544	2009.4280	160.5	0.33			
20582+3510	COU1813	2009.4335	308.9	1.16			
21000+4004	KUI 103AB	2009.4335	356.2	0.42	182.6	0.64	Lippincott 1975
21000+4004	KUI 103AB	2009.4280	357.1	0.43	44.0	0.54	Baize 1989
					44.0	0.54	Baize 1991
					40.5	0.60	Heintz 1994
					32.8	0.31	Docobo & Ling 1994
					336.9	0.23	Soderhjelm 1999
					12.4	0.35	Mante 2000
					12.4	0.43	Pourbaix 2000
21018+3916	STF2746	2009.4391	321.1	1.19			
21089+1748	HU 365	2009.4335	19.9	1.03			
21111+1704	HEI 187	2009.4335	255.7	1.13			
21115+4115	STT 431AB	2009.4391	125.2	2.62			
21115+4115	STT 431AB	2009.4281	125.3	2.61			
21143+4109	STT 432	2009.4391	114.8	1.33			
21161+4101	COU2229	2009.4281	272.1	0.78			
21171+4312	A 401	2009.4391	219.7	0.41			
21328+3904	A 1443	2009.4391	240.4	0.27			
21328+3904	A 1443	2009.4281	240.7	0.25			
21334+3058	COU 732Aa,Ab	2009.4336	264.8	0.49			
21356+3446	COU1481	2009.4281	171.7	0.64			
21363+1627	HDS3076	2009.4336	262.5	0.34			
21380+4153	A 402	2009.4281	45.9	0.85			
21421+4414	A 403	2009.4281	77.7	0.48			

technique doesn't work for weak objects when single photon events are strongly dominant in the speckle image.

Table 2 contains 189 measurements pertaining to 144 binary or multiple stars. The format for presentation of these measurements is not the same as in our previous publication (Orlov et al. 2009). We include three new columns for ephemerides of binaries with known orbital elements. Column 1 contains the epoch-2000 coordinates in the format used in the Washington Double Star (WDS) Catalog (Worley & Douglass 1997). The second column gives the name of the star or discoverer designation. The third column gives the epoch of the observation in fractional Besselian year. The two following columns contain the measured position angles θ given in degrees and angular distances ρ in arcseconds. The last three columns show ephemerides calculated for the date of observation and references to publications in which orbital elements can be found. As one can see, some orbits give very discrepant position of the secondary.

4. CONCLUSION

A program of speckle observations has been started at the Observatorio Astronómico Nacional telescopes, with the goal of obtaining astrometric data of double stars. This study started with well-known binaries from the WDS catalogue. One hundred seventy five position angle and separation measures for one hundred sixty three binaries have been presented, a subset of which has been used to determine measurement precision. We only present here the cases where the binary was clearly resolved. The results on binaries which demand more detailed analysis will be reported in subsequent publications.

The speckle interferometry program at the OAN telescopes is supported by the Direccion General de Asuntos del Personal Académico (Universidad Nacional Autónoma de México, Mexico) under projects IN104910 and IN113308 (PAPIIT).

REFERENCES

Alzner, A. 2001, IAUDS, Inf. Circ. 144
Aristidi, E., et al. 1999, A&AS 134, 545
Ávila, R., Cruz-González, I., & Tapia, M. 2003, RevMexAA (SC), 19, 121
Baize, P. 1981, A&AS, 44, 199
———. 1986, A&AS, 65, 551
———. 1989, IAUDS, Inf. Circ. 107
———. 1991, A&AS, 87, 49
———. 1992a, IAUDS, Inf. Circ. 116
———. 1992b, IAUDS, Inf. Circ. 117
———. 1993a, IAUDS, Inf. Circ. 120
———. 1993b, A&AS 99, 205
———. 1993c, IAUDS, Inf. Circ. 121
———. 1994, A&AS 106, 267
Couteau, P. 1990, IAUDS, Inf. Circ. 112
Christou, J. C., Hege, E. K., Freeman, J. D., & Ribak, E. 1986, J. Opt. Soc. Am., A, 3, 204
Docobo, J. A., & Ling, J. F. 1994, IAUDS, Inf. Circ. 124
———. 1998a, IAUDS, Inf. Circ. 136
———. 1998b, IAUDS, Inf. Circ. 135
———. 2002, IAUDS, Inf. Circ. 147
Docobo, J. A., Balega, Y. Y., Ling, J. F., Tamazian, V., & Vasyuk, V. A. 2000, AJ, 119, 2422
Erceg, V. 1975, Bull. Obs. Astron. Belgr., 126, 50
Hartkopf, W. I., et al. 2000, AJ, 119, 3084
Heintz, W. D. 1965, Veroff. Sternw. Munchen, 7, 7
———. 1975, ApJS, 29, 331
———. 1982, A&AS, 47, 569
———. 1994, AJ, 108, 2338
———. 1995, ApJS, 99, 693
Ling, J. F. 1999, IAUDS, Inf. Circ. 137
Lippincott, S. L. 1975, AJ, 80, 833
Mante, R. 1994, Obs. Trav. Soc. Astron. France, 39, 21
———. 1997, Obs. Trav. Soc. Astron. France, 52, 44
———. 1999, IAUDS, Inf. Circ. 138
———. 2000, IAUDS, Inf. Circ. 142
Orlov, V. G., Voitsekhovich, V. V., Mendoza-Valencia, G. A., Svyryd, A., Rivera, J. L., Ortiz, F., & Guerrero, C. A. 2009, RevMexAA, 45, 155
Orlov, V. G., Voitsekhovich, V. V., Sánchez, L. J., & Garfias, F. 2007, RevMexAA, 43, 137
Popovic, G. M. 1970, Bull. Obs. Astron. Belgr., 28, 141
———. 1972, Bull. Obs. Astron. Belgr., 29, 31
———. 1998, IAUDS, Inf. Circ. 136
Popovic, G. M., & Pavlovic, R. 1995a, Bull. Obs. Astron. Belgr., 151, 45
———. 1995b, IAUDS, Inf. Circ. 125
Popovic, G. M., Pavlović, R., & Zivkov, V. 2000, A&AS, 144, 211
Pourbaix, D. 2000, A&AS, 145, 215
Seymour, D., Mason, B. D., Hartkopf, W. I., & Wycoff, G. L. 2002, AJ, 123, 1023
Soderhjelm, S. 1999, A&A, 341, 121
Tokovinin, A., Mason, B. D., & Hartkopf, W. I. 2010, AJ, 139, 743
Voitsekhovich, V. V. Sánchez, L. J., Orlov, V. G., Garfias, F., & Benitez, R. 2005, RevMexAA, 41, 399
Worley, C. E., & Douglass, G. G. 1997, A&AS, 125, 523
Zulevic, D. J. 1969, Bull. Obs. Astron. Belgr., 27, 55
———. 1986, IAUDS, Inf. Circ. 98
———. 1995, IAUDS, Inf. Circ. 127
———. 1996, Bull. Obs. Astron. Belgr., 153, 79
———. 1997, Bull. Obs. Astron. Belgr., 155, 109

C. A. Guerrero, V. G. Orlov, F. Ortiz, J. L. Rivera, and V. V. Voitsekhovich: Instituto de Astronomía, Universidad Nacional Autónoma de México, Apdo. Postal 70-264, Cd. Universitaria, 04510 México D. F., Mexico (cguerrero, orlov, fortiz, jrivera, voisteko@astroscu.unam.mx).