

Speckle Interferometry of Nearby Multiple Stars. IV. Measurements in 2004 and New Orbits

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Abstract—The results of speckle interferometric observations of 104 binary and 6 triple stars performed at the BTA 6 m telescope in 2004 October are presented. Nearby low-mass stars are mostly observed for the program, among which 59 there are new binaries recently discovered by the Hipparcos astrometric satellite. Concurrently with the diffraction-limited position measurements we obtained 154 brightness ratio measurements of binary and multiple star components in different bands of the visible spectrum. New, first-resolved binaries are the symbiotic star CH Cyg with a weak companion at 0.043'' separation and the pair of red dwarfs, GJ 913 = HIP 118212. In addition, we derived the orbital parameters for two interferometric systems: the CN-giant pair HD 210211 = HIP 109281 ($P=10.7$ yr) and the G2V-K2V G2V-K2V binary GJ 9830 = HIP 116259 ($P=15.7$ yr).

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1. INTRODUCTION

This is the fourth paper in the series of publications with the data on speckle interferometry observations of binary and multiple stars performed with the BTA 6 m telescope of the Special Astrophysical Observatory of the Russian Academy of Sciences using a new detector system based on a 3-stage image intensifier and a fast CCD [1]. The main objects of the program are nearby low-mass stars with a considerable, of the order of $10^\circ/\text{yr}$, relative motion of the components, which makes them good new candidates for the calculation of visible orbits. Around half of these stars are new binaries discovered by the Hipparcos astrometric satellite [2]. The regular speckle interferometric observations of new Hipparcos binaries have been carried out at the BTA telescope since 1998 [3–5]. In addition, some early-type systems that are interesting for interferometric monitoring were included in the program. In particular, the Orion Trapezium members were observed in the visible range to reveal the relative motion of the components.

2. OBSERVATIONS AND RESULTS

The measurements are derived from speckle interferometry [6] observations taken at the BTA 6 m telescope of the Special Astrophysical Observatory during the period October 23 through November

1, 2004. During the observing period, the seeing changed between 1'' and 5''. On October 25/26, the seeing was 0.8''–1''. Note that even in the nights of poor seeing, speckle interferometry allowed us to perform speckle measurements of bright stars with a diffraction-limited angular resolution.

The instrumentation, observing procedure, data reduction, and calibration have already been described in the previous papers of this series [3–5]. The high sensitivity of the detector allows us to measure stars up to the 15th magnitude with a diffraction-limited resolution.

In this paper the results of 181 measurements of the relative positions of 104 binary stars (Table 1) and single measurements for 6 triple stars (Table 2) are presented. For each system the tables give four identifier numbers (the Hipparcos Catalog number, the name or the number from other catalogs, the discoverer designation, and the Washington Double Star Catalog coordinates, J2000.0). The identifier numbers are followed by the observation date as a fraction of the Besselian year, the measured position angle θ in degrees and its error σ_θ , the measured angular distance ρ in milliarcseconds (mas) and its error σ_ρ , the observed magnitudes difference Δm and its uncertainty $\sigma_{\Delta m}$, the center wavelength λ of the filter used to make the observation (nm), and the FWHM of the filter passband $\Delta\lambda$. For triple stars, Table 2

presents also the designations of the subsystems. The measured distances between the components of the systems range from 23 mas for θ^1 Ori C to 1622 mas for HIP 103810. The separation accuracy depends on many parameters; first of all, on the atmospheric conditions. For the majority of measurements, it is equal to 2–3 mas; however, for the most wide pairs with a separation of $>1''$, the error may reach 6–8 mas. The errors of the position angle measurements are 0.3° – 1.0° . Comments on the measurements of individual stars are given in the next section.

It is known that in speckle interferometry, the ensemble average modulus of the Fourier transform of a series of speckle images defines the position angles of binary stars with a $\pm 180^\circ$ ambiguity. To avoid this uncertainty, it is necessary to reconstruct not only the modulus but also the phase of the observed source [7, 8]. This requires a large number of additional com-

putations. In binary star speckle interferometry, we solve the problem of position angles using a simple approach proposed by Walker [9]. In this method we calculate the modulus of the Fourier transform of the product of the speckle interferograms and an exponential in addition to the measured modulus of the Fourier transform. From the measurements of the two moduli the location of the complex zeros of the analytical continuation of the Fourier transform of the unknown image can be found and the true image of a binary reconstructed. Problems arise when the components of a binary have similar magnitudes or when the differential speckle photometry of the pair is seriously noise-limited. The θ measurements with the $\pm 180^\circ$ ambiguity are marked with asterisks in Table 1.

Table 1. Double star measurements

HIP No.	Name/ Catalog No.	Discoverer designation	Coord. 2000.0	Epoch 2004.0+	θ , deg	σ_θ	ρ , mas	σ_ρ , mas	Δm	$\sigma_{\Delta m}$	$\lambda/\Delta\lambda$, nm
68	BD+16 5027	BAG 18	00008+1659	.8318	22.3	0.3	560	2	2.68	0.04	800/110
201	HD 225000	HDS 2	00026+1841	.8372	123.3*	1.0	80	2	2.34	0.05	545/30
689	HD 375	HDS 17	00085+3456	.8237	347.9	0.5	64	2	0.20	0.04	600/30
823		HDS 23	00101+3825	.8237	91.7*	1.18	72	2	0.00	0.21	800/110
1055	BD+19 20	HDS 29	00132+2023	.8238	169.0	0.3	664	2	1.11	0.06	800/110
1987	HD 2057	HDS 56	00252+4803	.8265	149.0*	1.1	238	5			545/30
2532	HD 2893	HDS 71	00321-1218	.8342	153.7*	0.4	292	2	0.41	0.10	545/30
3361	BD+12 81	HDS 93	00428+1249	.8211	71.3	0.3	247	2	1.44	0.03	600/30
3669	BD+42 170	HDS 102	00469+4339	.8320	125.6	0.6	152	2	1.06	0.03	800/110
4267	ADS 746	STT 20	00546+1911	.8212	188.0	0.4	540	3	1.05	0.05	545/30
				.8212	188.0	0.4	539	3	1.05	0.05	600/30
				.8212	187.7	0.4	540	3	0.99	0.05	850/75
				.8237	188.5	0.4	544	3	1.00	0.05	545/30
				.8237	188.5	0.4	542	3	0.98	0.05	600/30
				.8237	188.4	0.4	540	3	0.80	0.05	800/110
				.8237	188.3	0.4	539	3	0.83	0.05	850/75
4809	HD 6009	HDS 134	01017+2518	.8154	318.8	0.3	89	2	0.21	0.04	600/30
4849	GJ 3071	HDS 135	01024+0504	.8155	135.3	0.3	275	2	1.68	0.03	600/30
5531	HD 6840	HDS 155	01108+6747	.8155	159.6	0.3	116	2	0.71	0.02	545/30
5674	HD 7169	HDS 160	01129+5136	.8373	54.6	0.4	181	2	2.00	0.02	545/30
5952	HD 7640	HDS 169	01166+1831	.8238	247.9	0.4	639	4	3.32	0.17	600/30

Table 1. (Contd.)

HIP No.	Name/ Catalog No.	Discoverer designation	Coord. 2000.0	Epoch 2004.0+	θ , deg	σ_θ	ρ , mas	σ_ρ , mas	Δm	$\sigma_{\Delta m}$	$\lambda/\Delta\lambda$, nm
6060	ADS 1040	STF 102	01178+4901	.8265	273.3	0.4	475	3	0.83	0.13	545/30
				.8265	273.9	0.6	474	5	0.47	0.37	800/110
7338		HDS 211	01345+7804	.8156	245.2	0.8	279	4	2.17	0.06	800/110
7397		HDS 213	01463+4059	.8239	202.0*	0.4	80	2	0.00	0.13	545/30
10022	HD 13102	COU 1067	02090+3540	.8374	30.2	0.5	196	2	0.00	0.25	545/30
10414		HDS 297	02142+0909	.8212	38.9	0.5	383	3	1.32	0.05	800/110
10660	HD 13865	HDS 302	02172+5838	.8374	243.7	0.5	392	3	2.73	0.09	545/30
11253	HD 14874	HDS 314	02249+3039	.8239	276.9	0.3	372	2	2.68	0.05	545/30
11352	HD 15013	HDS 318	02262+3428	.8157	185.4	0.4	124	2	0.00	0.17	600/30
11474	HR 719	KUI 8	02280+0158	.8213	37.3	0.3	502	3	0.25	0.04	545/30
				.8213	37.2	0.3	501	3	0.23	0.02	545/30
				.8213	37.4	0.3	505	3	0.18	0.02	800/110
				.8239	37.6	0.3	504	3	0.25	0.25	545/30
				.8239	37.6	0.3	504	3	0.23	0.04	600/30
				.8240	37.5	0.3	505	3	0.00	0.18	800/110
12495	ADS 2018 Aa	CHR 208	02407+6117	.8264	269.2*	0.7	289	3			545/30
12552	HD 16656	COU 1511	02415+4053	.8374	65.0	0.7	135	2	0.65	0.06	545/30
13308	ADS 2165	BU 1316	02512+6023	.8264	297.7*	0.5	317	3			545/30
14075	HD 18774	HDS 385	03014+0615	.8157	166.2	0.4	162	2	0.00	0.17	800/110
14230	HD 18940	HDS 389	03035+2304	.8157	23.1	0.5	76	2	1.73	0.06	545/30
				.8266	23.8	1.7	73	3			545/30
14669	GJ 125	HDS 404	03095+4544	.8213	240.5	0.3	83	2	1.59	0.05	800/110
14864	GJ 3206	HDS 407	03119+6131	.8214	156.3	0.3	600	2	1.51	0.03	800/110
14929	HD 19895	HDS 408	03125+1857	.8158	122.0	1.6	26	2	0.00	0.36	545/30
15309	ADS 2436	STT 52	03175+6540	.8156	59.1	0.4	485	2	0.45	0.05	545/30
				.8156	59.6	0.4	484	2	0.48	0.03	600/30
				.8156	59.8	0.4	484	2	0.33	0.09	800/110
15737	63 Ari	HDS 423	03228+2045	.8267	292.9	0.5	416	4	3.36	0.12	700/30
16025	HD 21183	HDS 430	03264+3520	.8158	244.2	0.4	279	2	1.76	0.03	545/30
18089	31 Tau	KUI 15	03519+0633	.8159	207.0	0.4	757	2	0.31	0.05	545/30
				.8159	207.2	0.4	757	2	0.37	0.09	600/30
				.8159	207.2	0.4	758	2	0.47	0.06	800/110
				.8267	207.3	0.4	758	2			545/30

Table 1. (Contd.)

HIP No.	Name/ Catalog No.	Discoverer designation	Coord. 2000.0	Epoch 2004.0+	θ , deg	σ_θ	ρ , mas	σ_ρ , mas	Δm	$\sigma_{\Delta m}$	$\lambda/\Delta\lambda$, nm
				.8267	207.5	0.4	758	2			600/30
				.8267	207.4	0.4	758	2			700/30
				.8267	207.6	0.5	758	4			850/75
				.8268	207.6	0.4	758	2			800/110
18370	HD 24431	HDS 494	03556+5238	.8266	177.7*	0.4	723	5			545/30
18856	BD+06 620	HDS 510	04025+0638	.8214	150.3	0.7	77	2	0.28	0.05	800/110
	HD 25811	BAG 4	04063+1952	.8158	229.0	0.9	74	2	0.24	0.27	545/30
19206	HD 26040	HDS 521	040700-1000	.8240	350.5	0.3	234	2	1.39	0.02	545/30
19270	SZ Cam	CHR 209	04078+6220	.8216	115.6	0.3	75	2	0.95	0.02	545/30
				.8266	115.9	1.9	74	3			545/30
19472	HD 285465	HEI 35	04102+1722	.8241	343.4	0.3	323	2	1.29	0.04	600/30
19591	HD 284163	CHR 14	04119+2338	.8214	5.7	0.3	280	2	1.24	0.02	800/110
20553	HD 27836	HDS 564	04242+1445	.8159	247.2	0.4	302	2	2.24	0.04	800/110
20777	DF Tau	THB 1	04270+2542	.8215	247.1	0.5	108	2	0.60	0.03	800/110
20895	HD 283646	HDS 576	04287+2613	.8241	140.4	0.5	147	2	0.18	0.14	800/110
21280	HD 285931	CHR 17	04340+1510	.8160	271.1	0.4	192	2	1.05	0.04	800/110
21762	HD 29608	CHR 154	04404+1631	.8242	44.2	0.3	226	2	1.35	0.03	800/110
21881	94 Tau	MCA 16	04422+2257	.8242	44.0	0.3	303	2	2.48	0.02	545/30
22550	ADS 3475	BU 883	04512+1104	.8241	55.6	0.3	96	2	0.00	0.11	545/30
				.8241	56.0	0.4	97	2	0.33	0.05	800/110
23699	HD 32641	STT 97	05056+2304	.8161	149.5	0.4	356	3	1.34	0.08	545/30
				.8161	149.4	0.4	358	3	1.32	0.04	800/110
				.8162	149.4	0.5	357	3	1.40	0.09	600/30
				.8216	149.6	0.4	354	3	1.16	0.02	545/30
				.8216	149.5	0.4	354	3	1.20	0.02	600/30
				.8216	149.4	0.4	357	3	1.15	0.02	850/75
				.8244	149.2	0.4	355	3	1.47	0.02	545/30
				.8244	149.1	0.4	356	3	1.48	0.02	600/30
				.8245	149.1	0.4	356	3	1.39	0.02	800/110
23772	HD 240622	HDS 666	05066+2630	.8268	207.4*	1.6	169	5			800/110
25499	115 Tau	MCA 19	05272+1758	.8269	94.7*	0.4	88	2	0.95	0.02	545/30
25565	IU Aur	HDS 721	05279+3447	.8268	49.4*	1.4	141	4			545/30
25733	ADS 4072	HU 217	05297+3523	.8268	253.9	0.4	604	3	1.70	0.11	545/30

Table 1. (Contd.)

HIP No.	Name/ Catalog No.	Discoverer designation	Coord. 2000.0	Epoch 2004.0+	θ , deg	σ_θ	ρ , mas	σ_ρ , mas	Δm	$\sigma_{\Delta m}$	$\lambda/\Delta\lambda$, nm
26220	θ^1 Ori A	PTR 1	05353-0523	.8161	0.3	1.6	203	2	2.66	0.13	800/110
				.8215	0.9	0.8	205	3	4.14	0.16	545/30
26221	θ^1 Ori C	WGT 1	05353-0523	.8216	189.8	2.4	23	2	1.06	0.11	545/30
29269	HD 39861	HDS 841	06102+8131	.8270	197.5	0.5	654	5			800/110
30272	ADS 4950 AB	STF 881	06221+5922	.8270	143.1	0.3	657	2			700/30
				.8270	143.7	0.3	657	3			800/110
				.8271	143.2	0.3	660	2			545/30
30920	GJ 234	B 2601	06294-0249	.8217	37.1	0.3	1359	3	2.77*	0.03	800/110
32132	BD+40 1685	HDS 930	06426+3955	.8244	20.4*	0.6	88	2	0.00	0.18	545/30
32313	GJ 2050	BAG 22	06448+7153	.8271	69.1*	0.7	545	7			800/110
33142	GJ 3412	HEI 334	06541+6052	.8271	186.3	0.8	187	3			800/110
35457	HD 56099	HDS 1018	07192+5908	.8272	16.8*	0.4	130	2	0.00	0.23	545/30
38619		HDS 1123	07545+6008	.8272	178.5*	0.5	688	6			800/110
39261	53 Cam	MCA 33	08017+6019	.8243	305.3	0.7	90	2	1.41	0.02	545/30
39402		HDS 1149	08033+5251	.8243	207.3	0.3	265	2	0.00	0.16	800/110
				.8272	208.1	0.6	266	3			800/110
46199	HD 81105	HDS 1353	09252+4606	.8244	153.7	0.3	361	2	2.48	0.03	600/30
94679	ADS 12239 AB	STT 371	19159+2727	.8231	160.4	0.3	881	2	0.27	0.20	545/30
				.8231	160.3	0.3	881	2	0.36	0.10	600/30
				.8231	160.1	0.3	881	2	0.27	0.07	800/110
				.8231	160.1	0.3	882		0.32	0.06	850/75
				.8258	160.5	0.3	882	2			545/30
				.8258	160.3	0.3	881	2			600/30
95178	HD 183678	HDS 2740	19218+7708	.8261	2.0*	0.3	333	5			800/110
95413	CH Cyg		19246+5014	.8151	24.1	2.1	43	2	2.03	0.04	545/30
				.8152	24.6	3.5	41	3	2.20	0.11	600/30
95995	GJ 762.1	MCA 56	19311+5835	.8150	75.0	0.3	110	2	0.29	0.03	600/30
96339	GJ 4114 A	BAG 27	19351+0828	.8232	3.8	0.3	284	2	0.17	0.06	800/110
96656	GJ 765.2	MLR 224	19391+7625	.8150	126.7	0.6	82	2	0.59	0.03	600/30
97496	ADS 12973 AB	AGC 11	19490+1909	.8149	28.4	0.4	74	2	0.39	0.05	545/30
				.8149	28.1	0.4	74	2	0.43	0.02	600/30
				.8149	28.3	0.6	74	2	0.38	0.06	800/110

Table 1. (Contd.)

HIP No.	Name/ Catalog No.	Discoverer designation	Coord. 2000.0	Epoch 2004.0+	θ , deg	σ_θ	ρ , mas	σ_ρ , mas	Δm	$\sigma_{\Delta m}$	$\lambda/\Delta\lambda$, nm
99874	HR 7744	MCA 60	20158+2749	.8259	327.8	1.3	91	2	2.92	0.11	850/75
101181	HD 195397	HDS 2932	20306+1349	.8260	356.5*	0.8	70	2	0.61	0.06	545/30
102357	GJ 804	CAR 2	20444+1945	.8260	139.5*	1.9	86	3			800/110
103502		HDS 2989	20582+4011	.8260	148.5*	0.5	241	2	1.04	0.11	800/110
103810	ADS 14575	STF 2751	21022+5640	.8152	354.3	1.3	1617	6			545/30
				.8152	353.6	1.3	1619	5			600/30
				.8152	354.8	1.3	1622	5			800/110
				.8234	354.4	1.3	1617	6			545/30
				.8234	354.9	1.3	1619	6			600/30
				.8234	354.8	1.3	1621	5			800/110
				.8316	354.5	1.3	1615	5			545/30
				.8317	354.7	1.3	1620	5			700/30
				.8317	354.6	1.3	1622	5			800/110
				.8342	355.2	1.3	1621	8			545/30
				.8369	355.2	1.3	1618	6			700/30
				.8369	356.0	1.3	1616	6			800/110
104075	TV Equ	HDS 3004	21051+0757	.8233	3.6	0.6	252	3	3.87	0.10	545/30
104565	GJ 4182	BAG 29	21109+2925	.8233	210.3	0.4	126	2	0.43	0.05	800/110
105187	BD+65 1572	HDS 3032	21185+6613	.8317	143.9	0.3	737	3			800/110
105259	ADS 14864 Aa	BAG 9	21193+5837	.8151	122.8	0.5	117	2	1.64	0.02	545/30
				.8151	121.9	1.2	115	3	3.28	0.13	800/110
				.8234	122.5	0.3	117	2	1.64	0.02	545/30
				.8235	122.0	1.7	114	4	3.45	0.15	850/75
105438	ADS 14894	STT 435	21214+0253	.8318	236.5	0.3	679	2	0.55	0.07	800/110
105947	HD 204236	HDS 3053	21274-0701	.8152	127.5	0.3	195	2	1.47	0.03	545/30
106059	HD 204827	HDS 3058	21290+5844	.8261	181.3*	0.9	93	2	0.88	0.04	545/30
				.8261	181.8*	0.7	93	2	0.92	0.03	700/30
106886	ADS 15184 Aa	MIU 2	21390+5729	.8262	234.2*	0.5	99	2	1.38	0.02	545/30
				.8262	233.9*	0.6	100	2	1.44	0.03	700/30
108842	HD 209421	HDS 3129	22029+1547	.8370	226.0	1.0	38	2	0.51	0.04	545/30
109281	HD 210211	HDS 3145	22083+2409	.8153	273.1	0.3	126	2	0.50	0.02	545/30
109951	HD 211276	HDS 3158	22161-0705	.8152	92.5	0.3	357	2	1.88	0.03	545/30
112695	HD 216027	HDS 3241	22493+1517	.8207	302.1	2.0	64	3	2.24	0.08	545/30

Table 1. (Contd.)

HIP No.	Name/ Catalog No.	Discoverer designation	Coord. 2000.0	Epoch 2004.0+	θ , deg	σ_θ	ρ , mas	σ_ρ , mas	Δm	$\sigma_{\Delta m}$	$\lambda/\Delta\lambda$, nm
				.8342	303.6	1.7	63	2	2.20	0.06	545/30
112970	HD 216606	HDS 3247	22527+6759	.8371	324.0	0.6	169	2	3.52	0.06	545/30
113852	HR 8778	HDS 3285	23034+5834	.8317	127.8	0.3	400	2	3.29	0.04	545/30
114444	HD 218793	HDS 3302	23107+0947	.8318	328.9	0.3	352	2	1.80	0.02	545/30
114922	GJ 893.4	HDS 3316	23167+1937	.8153	275.3	0.5	126	2	0.15	0.17	800/110
				.8208	275.2	0.3	126	2	0.00	0.16	800/110
114927	BD+33 4679	HDS 3315	23167+3441	.8208	211.7	0.4	195	2	0.34	0.06	800/110
115666	ADS 16748 AB	HO 489	23260+2742	.8154	223.0	0.4	521	3	0.00	0.30	545/30
				.8154	223.3	0.4	519	3	0.37	0.03	600/30
				.8154	223.1	0.4	517	3	0.76	0.02	800/110
				.8207	222.8	0.4	517	3	0.00	0.30	545/30
				.8207	223.3	0.4	517	3	0.34	0.05	600/30
				.8207	223.5	0.4	518	3	0.79	0.02	800/110
				.8207	223.3	0.4	517	3	0.91	0.04	850/75
				.8372	222.7	0.4	520	3	0.00	0.30	545/30
				.8372	223.3	0.4	519	3	0.64	0.03	700/30
				.8372	223.3	0.4	517	3	0.76	0.02	800/110
116259	GJ 9830	HDS 3356	23334+4251	.8236	152.1	0.6	99	2	2.45	0.03	545/30
116294	HD 221630	HDS 3357	23338-0508	.8371	77.7	0.3	690	3	2.02	0.08	545/30
116310	ADS 16836	BU 720	23340+3120	.8236	97.3	0.3	550	2	0.38	0.04	600/30
116810		HDS 3363	23405+2959	.8209	240.3	0.3	869	3	1.75	0.04	800/110
118212	GJ 913		23587+4644	.8210	74.2	0.9	62	2	1.36	0.03	850/75
118287	ADS 17151	A 1498	23595+5441	.8209	87.7	0.3	375	2	0.12	0.06	545/30
				.8209	87.5	0.3	374	2	0.54	0.02	600/30
				.8209	87.2	0.3	374	2	1.11	0.07	800/110
				.8373	87.6	0.3	376	2	0.00	0.20	545/30
				.8373	87.2	0.4	376	2	0.76	0.05	700/30

The differential measurements of magnitude differences Δm between the components were performed concurrently with the position measurements of the major part of the studied stars. In Tables 1 and 2 we give 142 Δm values for binaries and 12 measurements for triples in different bands. The uncertainty of the Δm estimates varies from 0.02 to 0.37 magnitudes. Photometric measurements are

more sensitive to seeing conditions than astrometric; therefore, Δm could not be derived with a seeing worth than $2''$. The main problem of differential speckle photometry with the bad seeing is that the star partially falls outside the detector's window ($3''$). The same difficulties arise during observations of wide pairs with $\rho > 1''$. An example is GJ 234, whose measurements of Δm are marked with asterisks and

Table 2. Triple star measurements

HIP No.	Name/ Catalog No.	Discoverer designation	Coord. 2000.0	Epoch 2004.0+	Comp.	θ , deg	σ_θ , mas	ρ , mas	σ_ρ	Δm	$\sigma_{\Delta m}$	$\lambda/\Delta\lambda$, nm		
5245	HD 6639	HDS 144	01071-0036	.8155	AB	224.7	0.4	233	2	1.75	0.04	800/110		
		BAG 12			AC	167.5	1.5	1223	6					
101955	GJ 795	KUI 99	20396+0458	.8232	AB	307.1	0.3	322	2	1.26	0.05	600/30		
		BAG 14			AC	105.2	0.4	164	2				1.44	0.04
					BC	119.8	0.3	479	2				0.18	0.07
111805	ADS 16138	HO 295	22388+4419	.8235	AB	153.8	0.3	314	2			545/30		
		BAG 15			AC	162.2	10.5	25	5					
					BC	153.1	1.0	290	5					
112170	ADS 16214	STT 476	22431+4710	.8235	AB	119.6	0.3	492	2	0.35	0.05	545/30		
					AC	130.7	0.4	502	3				1.20	0.05
		HU 91			BC	209.1	1.5	97	3				0.86	0.05
116384	GJ 900	MEL 9	23350+0136	.8208	AB	335.7	0.3	610	2	2.56	0.06	800/110		
					AC	345.7	0.4	722	4				3.18	0.22
116726	ADS 16904	A 643	23393+4543	.8154	AB	138.9	0.3	250	2	0.11	0.02	545/30		
					AC	143.8	0.5	216	2				0.98	0.03
		CHR 149			BC	291.6	3.1	39	3				0.86	0.02

probably overestimated because the frame window cuts the speckle images.

So far, 12 orbits for new Hipparcos binaries have been published based on speckle interferometry with the BTA telescope [10, 11]. Using the 2004 observations and the newest 2006 measurements, we can derive orbital parameters for two more Hipparcos binaries: HIP 109281 and HIP 116259. The method of orbit computation is described in our previous paper [10]. New relative orbits of the systems are plotted in fig. 1 and 2, and short comments on the orbits are given in the next section.

3. COMMENTS ON INDIVIDUAL STARS

HIP 5245 (see Table 1). The faint tertiary component (Bag 12) in this K0 system was first found in the K band with the BTA 6 m telescope in 1999 [3]. It turned out to be 3 magnitudes fainter than the main component. A very weak sign of the component at a distance of 1.2'' from the A star was seen through the 800/110 nm filter in the 2004 observations. Its magnitude could not be estimated because of the noise in the power spectrum.

HIP 7338. Nine interferometric observations and one Hipparcos measurement of this pair of red dwarfs allowed us to confidently define half of its relative motion ellipse. The resulting orbit, with a period of 23 yrs, and the semimajor axis of $a=0.20''$ under $\pi_{Hp}=28.7$ mas gives a mass-sum of the system of $0.7 M_\odot$. However, the discrepancies between the measurements and the calculated positions are still very high. It is possible that the first Hipparcos observation had a large error, which may be explained by the faintness of the companion (magnitude fainter than 13.5). It will probably take a few more years to define the reliable orbit for the pair.

Our differential photometry carried out after 1999 shows that at 800 nm the magnitude difference between the components is 2.2 ± 0.1^m . Based on the parallax value $\pi_{Hp}=28.7$ mas, the integral visible magnitude $m_V=10.64$, and the color index $V-I=1.35$ in the Cousins system [2], we derived the absolute I magnitude of the secondary as $I_B=9.0$. This corresponds to the M5 spectral type. The specified differential photometry of the pair suggests a lower temperature of the secondary compared to that proposed in the first paper of the series [3].

HIP 109281

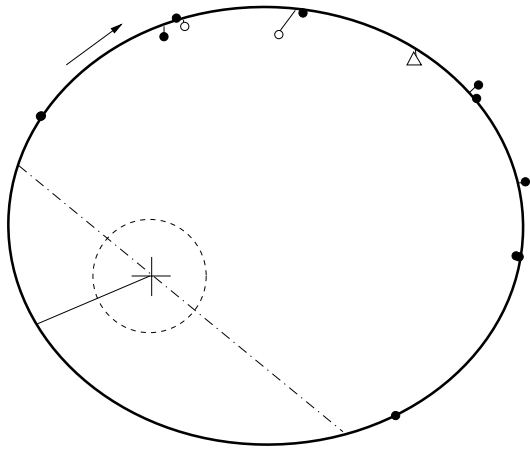


Fig. 1. Apparent ellipse representing the orbital elements for HIP 109281. The BTA speckle interferometric data are indicated by filled circles, the speckle interferometric measurements performed by Horch et al. are shown by open circles, and the Hipparcos measurement is shown as an open triangle. Residual vectors for all measurements are plotted, but in some cases they are smaller than the points themselves. The orbital motion direction is indicated by an arrow. The solid line shows the periastron position, while the dash-and-dot line represents the line of nodes. The dashed circle around the position of the primary has an angular radius of $0.02''$ corresponding to the diffraction limit of the 6 m telescope in the V band. North is up and east is to the left.

HIP 39402. This is another system of M dwarfs at a distance of 31 pc from the Sun. Possibly, its orbital period is 26 yrs and the semimajor axis is $0.28''$. However, the scattering of speckle data is abnormally large under this solution. We do not exclude that the significant deviations of the measurements are caused by the presence of a third star in the system, as mentioned in our 1999 observations [4].

HIP 95413 = CH Cyg. A symbiotic system with the M6 giant main component resolved for the first time. Presently, a generally accepted model of the system does not exist; and there is no explanation for the nature of the star's activity. Most researchers suggest a triple model for CH Cyg: the M6III giant and a white dwarf form the inner orbit with a period of 756 days, while the third component moves in the outer orbit with a period of 14.5 yrs. The tertiary star could be a G-K dwarf or a giant [12–14]. However, the photometric and spectroscopic variability of the star can also be satisfactorily interpreted by a binary model [15, 16]. Detailed analysis of the model limitations from the speckle observations will be made in a separate paper. Here we draw attention to only two important details. First, at a distance of 270 pc [17], the discovered companion can only be connected with the long-period orbit in the system. Second, the posi-

HIP 116259

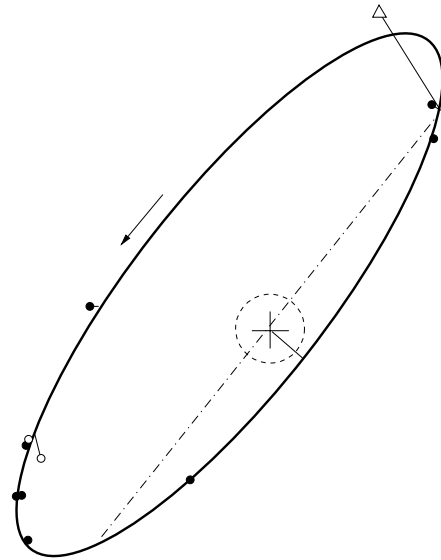


Fig. 2. Apparent ellipse representing the orbital elements for HIP 116259.

tion angle of the pair ($\approx 25^\circ$) is almost perpendicular to the extended nebulosity (position angle $\approx 165^\circ$) discovered in UV continuum, [OIII] and Balmer lines with the HST WFPC2 [18].

HIP 99874 = 23 Vul = MCA 60. The main component of this pair is a K3-type giant. A faint companion ($\Delta m = 2.92$ in the I band) is moving with acceleration in the direction of the main star in a highly inclined orbit. The pair was also observed with the BTA 6 m telescope in 2002. However, the results were never published because of bad weather conditions during the observations: 2002.7980, $\theta = 326.8^\circ$, $\rho = 156$ mas. The quadrants of all speckle observations collected in the 4th Catalog of Interferometric Measurements of Binary Stars [19] have to be changed by 180° . The third star in the system, CHR 94, has never been detected in our observations.

HIP 109281. The elements of the interferometric orbit can now be derived for this pair of evolved stars using 13 speckle measurements with the BTA 6 m telescope and the WIYN 3.5 m telescope [20], and using the first measurements by Hipparcos:

$$P = 10.736 \pm 0.078 \text{ yrs,}$$

$$T = 1997.812 \pm 0.025,$$

$$e = 0.518 \pm 0.010,$$

$$a = 0.095 \pm 0.001'',$$

$$i = 151.2 \pm 2.2^\circ,$$

$$\Omega = 50.4 \pm 3.2^\circ,$$

$$\omega = 292.5 \pm 3.2^\circ.$$

Note that one new measurement with the 6 m telescope made in 2006 was used to calculate the

parameters (not included in Table 1). The list of position measurements, together with the deviations from calculated values, is presented in Table 4. The graphical presentation of the orbit is shown in fig. 1. With the Hipparcos parallax value $\pi_{Hp}=12.65\pm 0.79$ mas [2], the mass-sum of the binary is $\Sigma M=3.2\pm 0.6 M_{\odot}$ (accuracy 19%).

HIP 111805 = Bag 15 (see Table 2). A close companion of the main star in the triple system is resolved marginally. Nevertheless, despite the significant error of the measurement, we decided to include its θ and ρ values in Table 2. The pair (G2V+K1V, P=551 d) was discovered spectroscopically by Duquennoy [21] and later resolved by speckle interferometry at the BTA telescope [3].

HIP 116259. The system with the G2 and K4 components [3] belongs to the old population of the Galaxy [22]. 11 interferometric measurements in the period from 1998 through 2006 allowed the determination of the visible ellipse of the system's motion and the orbital parameters:

$$P = 15.70\pm 0.23 \text{ yrs,}$$

$$T = 2005.49\pm 0.01,$$

$$e = 0.536\pm 0.007,$$

$$a = 0.220\pm 0.002'',$$

$$i = 75.1\pm 0.4^{\circ},$$

$$\Omega = 141.5\pm 0.3^{\circ},$$

$$\omega = 89.5\pm 0.8^{\circ}.$$

The deviations of the measurements from the computed values are given in Table 5. The first measurement by Hipparcos was not taken into account in the calculations. In addition to the data from Table 1, we have made use of the newest measurement made at the BTA 6 m telescope in 2006. The ellipse of the interferometric orbit is shown in fig. 2. The total mass of HIP 116259 is $\Sigma M=1.56\pm 0.18 M_{\odot}$ (accuracy 12%) under $\pi_{Hp}=30.24$ mas [2]. As for all Hipparcos new binaries, the parallax error plays a definitive role in the total error of the mass estimate, but not the orbital elements. The spectroscopic orbit of the pair [23] has similar characteristics.

HIP 118212 = GJ 913. This nearby, $\pi_{Hp}=58$ mas [2], M-type star was included in the program as a possible binary. It is one of 1561 stars in the Hipparcos Catalog marked with an X flag, which means that only a stochastic solution for their astrometry was found. A part of these stars can be non-single objects, while the other part can be explained by the failure in data reduction. An attempt to improve the parallax of HIP 118212 and to define the character of its motion from the Hipparcos astrometry has recently been made by Goldin and Makarov [24]. Using the results of independent observation reductions by two consortia, FAST and NDAC, they calculated a new

parallax value for the star, $\pi_{Hp}=67$ mas, and defined the orbit with a period of 885 days.

We first resolved a faint ($\Delta m=1.4$ in the *I* band) close ($\rho=62$ mas) companion of HIP 118212 with the BTA 6 m telescope in the 850/75 nm filter. Our measurement does not fit the calculated position on the orbit of Goldin and Makarov [24]. The reason for this discrepancy—a new companion or the wrong orbit—can be established in the immediate future using new speckle observations of this presumably fast-moving pair.

4. UNRESOLVED OBJECTS

A total of 26 objects were not resolved in the course of the observations. They are listed in Table 3. Due to the marginal weather conditions, some of the binaries with a limiting magnitude difference for speckle interferometry (around 3.5 magnitudes) were not resolved. One example of such a system is HIP 97579, with a remote companion ($\rho=687$ mas, $\Delta m=3.46$) given in the Hipparcos Catalog. The power spectrum of this pair can be traced up to the limiting frequency of the telescope, but its noisiness could be the reason why the secondary was not detected.

Another unresolved star HIP 19270=ADS 2984A is a southern component of the wide visual pair. It was observed under poor seeing conditions as a reference source for its northern neighbor ADS 2984 B, which is known as SZ Cam—a distant occultation binary with early-type massive components.

One more unresolved star, HIP 97607 = CHR 89 of B2IVe spectral type, appeared in the lists of new binaries after speckle observations with the CFHT 3.6 m telescope in 1985 [25]. Another observation of the star was obtained in the same year by the same authors using the MAYAL 3.8 m telescope at Kitt Peak [26]. However, neither the Hipparcos observations nor the following BTA speckle interferometry confirmed the duplicity. Despite the poor seeing conditions, our observations in 2004 allowed us to study the power spectrum up to the highest spatial frequencies. We do not exclude the possibility that the pair will prove to be a short-period system ($P\approx 50$ yr), which is presently unresolved.

The history of speckle observations of HIP 98538 = CHR 118 is similar to the history of the previous star CHR 89. After the only measurement in 1985 [27], the companion has never been observed again. Note that the confirmation of the binary nature of the CH star CHR 118 is of great importance for the explanation of the properties of this rare stellar type.

Following the accurate orbit of the spectroscopic and interferometric binary HIP 101382 = HD 195987

Table 3. Unresolved stars

HIP No.	Other catalog No.	Coord. 2000.0	Epoch 2004.0+	$\lambda/\Delta\lambda$, nm	Note
916	GJ 3012	00114+5821	.8210	850/75	X
1092	GJ 3015 B	00136+8040	.8210	800/110	X
1295		00162+1952	.8211	800/110	X, S
1475	GJ 15 A	00184+4401	.8236	850/75	S
1860	GJ 1010 A	00235+7711	.8211	800/110	X, S
3362	GJ 29.1	00428+3533	.8320	800/110	G
7765	ADS 1307 B	01399+1516	.8238	800/110	X, S
7981	HR 493	01425+2016	.8238	545/30	O
16445	GJ 143.3	03318+1419	.8214	800/110	X, S
19270	ADS 2984 A	04078+6220	.8266	545/30	
20222		04200+3629	.8243	800/110	X
31635	GJ 239	06372+1734	.8217	600/20	S
36834	GJ 277.1	07345+6256	.8271	800/110	S
97579	HDS 2823	19500+3158	.8232	545/30	
97607	HR 7554	19503+0754	.8259	545/30	
98538	HD 189711	20011+0931	.8259	800/110	
101382	GJ 793.1	20329+4154	.8260	545/30	
102851	GJ 808.2	20502+2923	.8233	600/20	X, S
103256	GJ 1259	20551+1311	.8233	600/20	
106886	ADS 15184 C	21390+5729	.8262	545/30	
	ADS 15184 D		.8262	545/30	
108467	GJ 842.2	21584+7535	.8235	800/110	S
112460	GJ 873 A	22468+4420	.8319	800/110	S
114941	GJ 4323	23169+0542	.8208	800/110	S
117779	GJ 910	23531+2901	.8236	800/110	X, S
117795		23533+5957	.8210	800/110	G
118310	ADS 17154 A	23598+0640	.8318	700/30	S

= GJ 793.1 with a period of 57.3 days [28], the separation between the components in the period of the BTA observations was only 9 mas. That explains our negative result because such a separation is smaller than the diffraction limit of the 6 m aperture. Earlier, Blazit et al. [29] reported the speckle interferometric resolution of the system with the CFHT 3.6 m telescope in 1985: $\theta=170^\circ$, $\rho=30$ mas. The ephemeris separation value in the period of their observation was also equal to 9 mas; therefore, the binary could not

Table 4. Position parameters and residuals of the measurements of the HIP 109281

Epoch	θ , deg	ρ , mas	$(O - C)_\theta$, deg	$(O - C)_\rho$, mas	Reference
1991.250	311.0	119	-1.2	-3	[2]
1998.774	32.5	68	0.3	1	[3]
1999.741	356.7	86	0.1	-4	[3]
1999.821	354.4	93	-0.1	1	[4]
1999.885	352.1	90	-0.6	-3	[20]
2000.764	333.1	97	0.1	-10	[20]
2000.872	331.1	108	0.2	-1	[5]
2002.736	301.4	131	0.2	4	This paper
2002.799	299.8	128	-0.5	1	This paper
2003.927	284.8	132	-0.2	3	This paper
2003.927	284.9	132	-0.1	3	This paper
2004.815	273.2	125	0.5	-1	This paper
2004.815	273.1	126	0.4	0	This paper
2006.690	239.4	96	0.0	0	This paper

be resolved at CFHT, which has a diffraction limit of ≈ 40 mas.

In the spectroscopic binary system HIP 103256 = GJ 1259, the companion’s mass is 7 times lower than the mass of the main K3V star [30]. The luminosities of a K3V star and a late red dwarf differ in the visible by 7–8 magnitudes, ruling out the possibility for speckle resolution of the components.

The system ADS 15184 C,D (HIP 106886) is a member of the OB star complex. The stars were included in the program as reference sources for the triple star ADS 15184 A = MIU 2, which includes both a spectroscopic pair and a remote O companion [31]. Mason et al. [32] observed the C and D components of ADS 15184 earlier and could not detect a sign of their multiplicity. It should also be taken into account that our observations were carried out under poor seeing conditions.

The nearby ($\pi_{Hp}=39$ mas) K5V star HIP 118310 = ADS 17154 Aa = Bag 31 was first resolved with the BTA 6 m telescope in 2001 with $\rho \approx 0.2''$. Three years later, the secondary was not detected despite the fact that the power spectrum was accumulated to the limiting frequencies. We conclude from this that the pair can show a fast orbital motion with a period of ≈ 10 years.

In the last column of Table 3, we present flags for the Hipparcos Catalog “problem” stars with the

Table 5. Position parameters and residuals of the measurements of the HIP 116259

Epoch	θ , deg	ρ , mas	$(O - C)_\theta$, deg	$(O - C)_\rho$, mas	Reference
1991.25	341.0	195	18.9	34	[2]
1998.775	83.0	105	0.4	6	[3]
2000.617	119.6	153	6.2	4	[20]
2000.759	114.7	154	-0.2	1	[20]
2000.865	115.6	157	-0.4	1	[5]
2000.873	115.6	157	-0.5	1	[5]
2001.761	123.5	177	-0.3	0	[5]
2001.761	123.8	174	0.0	-3	[5]
2002.796	130.9	185	-0.3	-3	This paper
2004.824	152.1	99	0.2	0	This paper
2006.690	319.3	146	-0.1	1	This paper
2006.946	321.9	161	-0.1	0	This paper

following astrometric solutions: G, motion with acceleration, X, stochastic solution for the photocenter motion, S, possible non-single system. Flag O stands for HIP 7981 with the computed Hipparcos astrometric orbit. Following this orbit, the binary is too close to be resolved with the 6 m telescope. As it follows from our earlier observations, up to 30–35% of the Hipparcos “problem” stars could be resolved using the speckle interferometry at the BTA 6 m telescope [5]. In the 2004 observations, only one out of six new stars in this category was resolved for the first time (HIP 118212). Other Hipparcos “problem” stars (HIP 916, 1092, 1475, 1860, 3362, 7765, 7981, 16445, 31635, 36834, 108467, 112460, 117795) still remain unresolved.

5. CONCLUSION

Speckle interferometric observations of 110 binary and multiple stars were taken in 2004 October at the BTA 6 m telescope with the diffraction resolution of the aperture: 19 mas in the 545/30 nm filter, 21 mas in the 600/30 nm filter, 28 mas in the 800/110 nm filter, and 29 mas in the 850/75 nm filter. Most of the objects in the program are nearby late-type dwarfs. About half of them are new pairs discovered by the Hipparcos astrometric satellite.

197 measurements of position angles and distances between the components of multiple systems

have been collected in Tables 1 and 2. The errors of the measurements range from 0.3° to 3.1° for the position angle and from 2 to 8 mas for the angular separation. The closest among the resolved pairs is θ^1 Ori C with a separation between the components of 23 mas, corresponding to 83% of the limiting resolution. The widest observed pair is ADS 14575 ($\rho=1.6''$), which is a standard star for the binary star speckle interferometry. In a separate table, we give a list of 26 stars that remained unresolved in 2004.

In this paper we presented 154 measurements of the brightness difference between the components of binary and multiple stars. In the last few years, this has become the standard procedure in stellar speckle interferometry and is significant for deriving the physical properties of studied stars.

The symbiotic system CH Cyg and the pair of red dwarfs HIP 118212 were resolved for the first time. The observations of the binary system CH Cyg are of particular importance because up to now, there has been no satisfactory model for this nearby symbiotic star, and the nature of its activity remains unclear. Nor has it been determined whether the carbon-oxygen white dwarf in the system is able to accumulate mass due to accretion from its cool companion until it approaches the Chandrasekhar limit and becomes a supernova SN Ia progenitor.

Using BTA speckle interferometry, we obtained first orbits for two binaries: the CN giant system HD 210211 = HIP 109281 with a period of 10.7 yrs, and the G2V-K4V pair GJ 9830 = HIP 116259 with a period of 15.7 yrs. Their orbital elements and (O–C) deviations from the predicted positions are presented in the paper.

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