Double and Multiple Star Measurements at the Southern Sky with a 50cm-Cassegrain and a Fast CCD Camera in 2008

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Abstract: Using a 50cm Cassegrain in Namibia, recordings of double and multiple stars were made with a fast CCD camera and a notebook computer. From superpositions of "lucky images", measurements of 149 systems were obtained and compared with literature data. B/W and color images of some remarkable systems are also presented.

Introduction

As has already been demonstrated in earlier papers in this journal, the accuracy of double star measurements can be significantly improved by the technique of "lucky imaging". Using short exposure times, only the best frames out of some thousands are registered and stacked. Thus, seeing effects are effectively reduced, and the resolution of a telescope can be pushed to its limits, even under non-optimum average seeing conditions. The accuracy of position measurements can even be better than this by about one order of magnitude. In total, 179 measurements of 149 double and multiple systems, mostly brighter than 10 mag, have been done. While in the majority of cases, not too many data are found in the literature to compare with, often with large scatter, 34 pairs with sufficiently well known separations could be used as reference for calibration. About 36 pairs are binaries with more or less well known orbits. In some cases, deviations from ephemeris data were found, in accordance with measurements from other authors.

Instrumental

The telescope is of Cassegrain type with aperture 50 cm and focal ratio of f/9. It is located on a guest farm in Namibia and owned by the *Internationale Amateur-Sternwarte* (IAS) [1]. The setup for recording was the same as I used earlier at home as well as at the southern sky [2-5]. In most recordings, I used a 2x Barlow lens (*Televue*) to extend the effective focal length to about 9 m (f/18). With my b/w-CCD camera (DMK21AF04, *The Imaging Source*) with pixel size 5.6 µm square, this results in a resolution of about 0.13 arcsec/pix. An exact calibration was obtained by an iterative method by measuring well documented double stars (see below). Generally, I used a red filter to reduce chromatic aberration of the Barlow lens, as well as the atmospheric spectrum. For systems with pronounced color contrast, I made additional recordings with green and blue filters in order to produce composite images. To roughly compensate the variation of sensitivity with wavelength, exposure in blue was typically set to two times that in red and green. Exposure times varied between 0.5 msec and 100 msec, depending on the star brightness. Under good seeing conditions, some systems were also recorded with exposures up to 0.5 sec, in order to image faint companions. The procedure of image processing was essentially the same as reported earlier. The yield of "lucky" frames ranged from several tens to more than a hundred frames, depending on the seeing. These were then re-sampled, registered (often manually), and finally automatically stacked. This process resulted in smooth intensity profiles, and in position measurements with sub-pixel accuracy.

Calibration

The image scale was calibrated by measuring a number of double stars with sufficiently well known separations. These are mainly selected from the WDS [6], and the so-called speckle catalog [7]. Data available up to fall 2010 are taken into account, as of writing this article. Criterion is that literature data can unambiguously be extrapolated to the actual date. This may even include binaries. In total, measurements of 34 such systems were obtained, which are contained in the table below, and are marked with shaded lines. The calibration constant was adjusted such that the sum of the residuals as well as the standard deviation assumed minimum values. For recordings with Barlow, statistical analysis resulted in a value of 0.132 arcsec/pix, with an error margin of +/- 0.5%. The standard deviation of the residuals (of the pairs used for calibration) is ±0.038 arcsec, with range between maximum and minimum of ±0.09 arcsec. The absolute total error margin is the sum of both contributions. While at small separations, the statistical error dominates, the possible error of the calibration constant becomes important at greater separations. A similar analysis was made for recordings without Barlow, resulting in a calibration constant of 0.257 arcsec/pix. In Figures 1 and 2, the final residuals of the separations and position angles are plotted for all pairs, for which extrapolation of literature data or even direct comparison is reasonable. It should be noted that the remaining scatter is due to possible errors of both literature data, and of own measurements. Because of the above limitation, the scatter appears relatively small, but in fact, it is much larger for other systems, which are not included here because of too few or less trustworthy literature data.

Position angles were measured by referring to star trails in east-west direction, which were obtained by superposing frames with short exposures, while the system was drifting across the field with the telescope drive shut off. This was done for every recording of any system in order to avoid errors, which may occur by slight misalignment of the mounting. The error margin was ±0.1 degree. The residuals of the position angles, delta PA, are plotted versus the separation rho in Figure 2. Deviations increase with decreasing separation, mainly because the lateral resolution is fixed by the pixel size, but also due to significant scatter of literature data. When taking into account only systems used for calibration of the image scale, statistics result in a standard deviation of ±0.33 degrees with range between maximum and minimum of +0.7

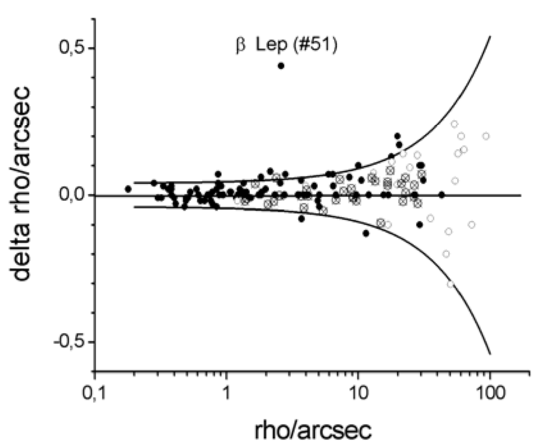

Figure 1: Plot of the residuals of rho versus rho. Semi-logarithmic scale. Full and open circles indicate systems recorded with and without Barlow, respectively. Circles with crosses represent systems, which have been used for calibration of the image scale. The curves mark the total error limits. The reason for the peculiar deviation of the pair beta Leporis, as indicated (the number refers to the notes below), is unclear, as both extrapolation of literature data seems to be fairly unambiguous, and the own measurement rather trustworthy, but differing. See text.

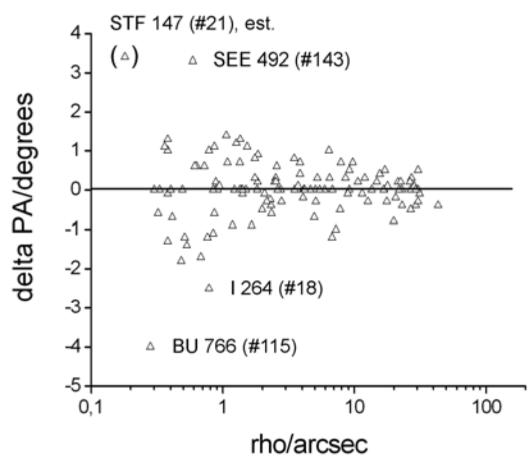

Figure 2: Plot of the residuals of the position angle versus rho. Semi-logarithmic scale. The increase of scatter towards small separations is caused by scatter of literature data, as well as by the fixed image resolution. Some pairs are indicated with numbers of corresponding notes below. STF 147 is not resolved, and the P.A. is only a rough estimate.

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and -0.9 degrees, respectively.

Results

All measurements are listed in the following table, which is followed by individual notes. Asterisks denote systems, for which images are shown below. These are chosen for different reasons. In general, they depict the image quality, which can be obtained with lucky imaging, which is often apparent by the diffraction rings. Images of close binaries are shown in Figure 3. Figures 4 and 5 illustrate the case of a binary (STF 2744 Aqr), of which the calculated orbit is still somewhat uncertain. It also compares the scatter of data from lucky imaging with that of speckle measurements. Other images show large delta m pairs (Figure 6), or interesting multiple systems (Figure 7). RGB composites are presented of pairs with marked color contrast (Figure 8). These should not be taken too seriously, because of the non-linear response of the CCD camera to large differences of brightness, combined with the strong variation with wavelength. In all images, north is down, and east is right. When indicated at the bottom, position angles and separations are as measured from the respective image.

A number of the systems listed here have also been recorded during the same stay in Namibia with a 40 cm Cassegrain telescope. The results have been published in a previous paper in this journal [4]. Generally, agreement was found within the error limits. In doubt, the present data may be more accurate, because of the larger telescope.

It may be noted that in several cases, data from lucky imaging had *a posteriori* been confirmed by speckle data of about the same epoch, within the error limits.

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Table 1: List of all measurements. Systems used for calibration of the image scale are marked by shaded lines. Names, positions and magnitudes are taken from the WDS. Position angles (P.A.) are in degrees, separations (rho) in arcseconds. N is the number of different recordings. Residuals delta are given, when extrapolation of literature data appears reasonable.

PAIR	RA + DEC	MAGS	P.A. meas.	rho meas.	DATE	N	delta P.A.	delta rho	NOTES
BU 391AB	00 09.4 -27 59	6.13 6.24	259.3	1.38	2008.725	1	~0	-0.02	1
I 701	00 20.2 -35 54	8.33 8.76	58.0	0.63	2008.749	1	+0.6	-0.02	2
LCL 119AB	00 31.5 -62 57	4.28 4.51	168.5	27.1	2008.725	1	+0.3	~0	3
I 260CD		4.60 6.54	250.1	0.32	2008.725	1	-0.6	-0.01	
STF 39AB-C	00 34.5 -04 33	7.10 8.65	44.2	19.9	2008.749	1	-0.8	+0.2	4
BU 395	00 37.3 -24 46	6.60 6.20	86.8 89.1	0.38 0.38	2008.727 2008.743	1 1	-1.3 +1.0	+0.02 +0.02	5
HJ 3388	00 42.6 -54 07	8.51 8.86	241.4	16.8	2008.724	1	~0	+0.04	6
HDO 182	00 42.7 -38 28	6.60 7.01	20.2	0.72	2008.725	1	+0.6	~0	7
I 47	00 51.9 -43 43	7.45 7.95	23.9	0.68	2008.749	1	-1.7	-0.02	8
DUN 2	00 52.4 -69 30	6.70 7.35	81.8	20.57	2008.725	1	-0.2	+0.17	9
GLI 4	00 53.0 -61 05	8.41 8.77	70.2	5.95	2008.743	1	~0	+0.07	10
S 390	00 58.2 -15 41	7.77 7.86	216.2	6.46	2008.749	1	+0.3	+0.03	11
HJ 3416AB	01 03.3 -60 06	7.58 7.67	128.8	5.08	2008.749	1	-0.3	-0.04	12
RST1205AB	01 08.4 -55 15	4.02 6.80	109.3	0.51	2008.727	1	-1.2	-0.01	13
RMK 2AB-C		4.02 8.23	240.5	6.76	2008.727	1	-1.2	-0.02	
			241.7	6.78	2008.747	1	~0	~0	
HU 1342	01 09.4 -56 36	7.78 8.25	331.2	0.38	2008.746	1	+1.3	~0	14*

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Table 1 continued

PAIR	RA + DEC	MAGS	P.A. meas.	rho meas.	DATE	N	delta P.A.	delta rho	NOTES
BU 1229	01 19.3 -34 29	8.51 8.74	275.9	0.76	2008.749	1	-1.2	-0.02	15
STF 113A-BC	01 19.8 -00 31	6.45 6.99	19.9	1.65	2008.749	1	-0.9	+0.04	16
HJ 2036	01 20.0 -15 49	7.40 7.61	339.9	2.29	2008.749	1	-0.3	-0.02	17
I 264AB	01 31.6 -53 22	8.36 8.84	29.0	0.78	2008.743	1	-3.0	-0.03	18
HJ 3447	01 36.2 -29 54	5.97 7.35	182.7	0.78	2008.725	2	+1.0	+0.01	19*
DUN 5	01 39.8 -56 12	5.78 5.90	188.7	11.46	2008.725	1	-0.1	-0.13	20
STF 147	01 41.7 -11 19	6.14 7.17	~113	~0.18	2008.727	1	+3.4	+0.02	21
HJ 3461AB	01 45.6 -25 03	5.38 8.50	21.7	5.06	2008.725	1	~0	~0	22
HJ 3475	01 55.3 -60 19	7.18 7.23	76.8	2.51	2008.750	2	+0.3	~0	23
STF 186	01 55.9 +01 51	6.79 6.84	245.9	0.88	2008.727	2	~0	~0	24
H II 58	01 59.0 -22 55	7.28 7.56	302.3	8.70	2008.749	1	-	-	25
STF 231AB	02 12.8 -02 24	5.72 7.71	234.9	16.9	2008.749	1	-	-	26
HTG 1	02 15.8 -18 14	8.49 9.25	154.9	1.85	2008.727	2	+0.9	+0.01	27
KUI 8	02 28.0 +01 58	7.09 7.63	38.7	0.49	2008.727	1	~0	-0.01	28
STF 274	02 31.5 +01 06	7.52 7.62	219.9	13.56	2008.727	1	~0	+0.05	29
STF 280	02 34.1 -05 38	7.98 7.97	346.1	3.68	2008.727	1	~0	~0	30
STF 299	02 43.3 +03 14	3.54 6.18	298.1	2.32	2008.727	1	-0.4	~0	31
VOU 36	02 51.3 +01 42	8.23 9.54	14.2	0.33	2008.727	1	~0	+0.03	32
STF 323	02 52.7 +06 28	7.81 7.92	278.3	2.75	2008.749	1	~0	~0	33
A 2413	02 57.2 +01 53	8.28 8.62	156.4	0.53	2008.727	2	-1.4	+0.01	34
HJ 3568	03 07.5 -78 59	5.70 7.70	225.6	15.4	2008.753	1	-	-	35
AC 2AB	03 18.4 -00 56	5.60 7.97	257.6	1.22	2008.727	2	~0	~0	36
DUN 14	03 38.2 -59 47	7.00 8.34	271.9	57.44	2008.753	1	~0	+0.14	37
DUN 17	04 01.0 -54 24	7.70 8.22	141.8	64.1	2008.753	1	-	-	38
RMK 3	04 17.7 -63 15	6.04 7.67	4.7	3.94	2008.753	1	+0.9	-0.03	39
RMK 4	04 24.2 -57 02	6.82 7.23	247.4	5.44	2008.753	1	~0	-0.05	40
HJ 3683	04 40.3 -58 57	7.33 7.45	90.1	3.68	2008.753	1	+0	+0.05	41
DUN 18	04 50.9 -53 28	5.61 6.24	58.0	12.67	2008.753	1	-0.3	+0.07	42
BU 314AB	04 59.0 -16 23	5.92 7.50	321.2	0.86	2008.753	1	+1.1	+0.04	43
STF 661	05 13.2 -12 56	4.43 6.77	356.8	2.15	2008.753	1	-0.3	+0.08	44
HJ 3750	05 20.4 -21 14	4.72 8.45	278.9	4.13	2008.753	1	~0	~0	45
HJ 3752AB	05 21.8 -24 46	5.44 6.58	91.5	3.51	2008.753	1	~0	~0	46
HJ 3752AC		5.44 9.2	104.0	63.3	2008.753	1	-	-	
DUN 20AB-C	05 24.8 -52 19	6.24 6.74	287.9	38.3	2008.753	1	-	-	47
HJ 3760AB	05 25.9 -35 21	7.84 8.35	222.3	7.38	2008.753	1	-	-	48
HJ 3760AC		7.84 10.7	287.4	29.35	2008.753	1	-0.4	-0.1	
HJ 3759	05 26.0 -19 42	5.87 7.30	317.6	26.75	2008.754	1	~0	~0	49
I 276	05 27.0 -68 37	6.66 6.95	160.7	1.41	2008.753	1	~0	-0.01	50
BU 320AB	05 28.2 -20 46	2.90 7.5	2.5	2.6	2008.754	1	~0	+0.44	51
BU 321AB	05 39.3 -17 51	6.69 7.83	159.6	0.53	2008.754	1	-	-	52

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Table 1 continued

PAIR	RA + DEC	MAGS	P.A. meas.	rho meas.	DATE	N	delta P.A.	delta rho	NOTES
HJ 3766AB	05 32.7 -17 49	2.58 11.2	156.9	35.50	2008.754	1	-0.1	-0.08	53*
HJ 3766AC		2.58 11.9	186.2	91.0	2008.754	1	-	-	
HDO 193	05 39.6 -34 04	2.64 12.5	358.4	13.98	2008.753	1	-	-	54*
H 6 40AB	05 44.5 -22 27	3.64 6.28	349.6	97.5	2008.754	1	-	-	55
HJ 3821AB	06 00.9 -21 00	8.13 9.31	214.1	18.00	2008.754	1	-0.4	+0.11	56
HJ 3821AC		8.2 12.5	88.9	19.84	2008.754	1	-0.1	+0.04	
I 3	06 12.5 -61 28	7.09 7.58	5.5	1.08	2008.753	1	+0.7	+0.01	57
ARG 12	06 05.3 -25 01	8.38 8.46	295.7	4.63	2008.754	1	~0	+0.03	58
HJ 3857AB	06 24.0 -36 42	5.73 9.83	253.9	13.09	2008.753	1	-1.1	+0.08	59
DUN 28AC		5.73 6.91	74.5	63.5	2008.753	1	-0.4	+0.15	
HJ 3869	06 32.6 -32 02	5.68 7.87	258.3	24.70	2008.749	1	~0	+0.09	60
SHJ 73	06 36.4 -18 40	5.79 7.38	263.7	17.6	2008.749	4	-0.3	+0.08	61*
BU 324AB	06 49.7 -24 05	6.56 7.93	211.2	1.83	2008.749	1	+0.2	+0.06	62
BU 324AC		6.56 8.28	282.2	30.4	2008.749	1	~0	+0.1	
STF 997	06 56.1 -14 03	5.27 7.14	339.8	2.79	2008.749	4	-0.3	+0.07	63*
CPO 7	06 58.6 -28 58	1.5 7.5	161.6	7.86	2008.749	1	+0.7	-	64*
HJ 3945	07 16.6 -23 19	5.00 5.84	50.8	26.8	2008.749	4	-0.5	+0.06	65*
RMK 6	07 20.4 -52 19	6.00 6.51	26.3	9.12	2008.743	1	~0	~0	66
HJ 3958	07 20.7 -52 12	6.88 9.14	279.2	28.4	2008.743	1	+0.1	~0	67
HJ 3962	07 20.9 -56 47	8.53 9.43	106.5	8.56	2008.743	1	+0.3	+0.06	68
RMK 11	09 47.1 -65 04	3.02 6.00	128.3	4.94	2008.743	1	-0.7	-0.02	69
RHD 1AB	14 39.6 -60 50	0.14 1.24	239.8	7.78	2008.719	2	-0.5	+0.02	70
DUN 166	14 42.5 -64 59	3.18 8.47	225.8	15.6	2008.743	1	+0.4	~0	71
HJ 4707	14 54.2 -66 25	7.53 8.09	276.3	1.06	2008.743	1	+1.4	+0.01	72
DUN 190AB	15 43.0 -58 07	8.06 9.74	89.8	4.97	2008.727	1	-	-	73
I 372AC		8.06 12.4	48.1	33.3	2008.727	1	-	-	
L 6477	15 47.9 -65 27	6.16 6.43	146.6	1.75	2008.743	1	+0.8	~0	74
DUN 195AB	15 54.8 -50 20	6.81 7.46	10.3	12.02	2008.725	1	+0.3	~0	75
DUN 195AC		6.81 11.0	300.8	26.8	2008.725	1	-	-	
HJ 4853	16 27.2 -47 33	4.51 6.12	334.5	22.88	2008.727	2	~0	+0.08	76
DUN 203	16 33.1 -60 54	7.92 8.21	279.7	21.9	2008.743	1	~0	-0.02	77
DUN 206AC	16 41.3 -48 46	5.71 6.76	265.2	9.80	2008.724	1	-	-	78
HJ 4876AD		5.71 10.5	160.5	13.37	2008.724	1	-	-	
HJ 4876AE		5.71 11.4	13.5	13.85	2008.724	1	-	-	
BSO 13AB	17 19.1 -46 38	5.61 8.88	255.7	10.02	2008.743	4	-1.3	+0.1	79
HDO 271	17 23.3 -47 28	5.5 10.8	55.9	44.8	2008.724	1	-	-	80
HJ 4942AB	17 25.4 -56 23	3.32 10.2	326.2	18.11	2008.724	2	-	-	81*
HJ 4942AC		3.32 12.2	65.5	42.0	2008.724	2	-	-	
A″D″		3.32 >12	39.4	47.2	2008.724	1	-	-	
HJ 5014	18 06.8 -43 25	5.65 5.58	4.3	1.75	2008.730	1	+0.3	~0	82

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Table 1 continued

PAIR	RA + DEC	MAGS	P.A. meas.	rho meas.	DATE	N	delta P.A.	delta rho	NOTES
BU 132AB	18 11.2 -19 51	7.01 7.13	188.5	1.41	2008.743	1	-0.1	+0.01	83
H 5 7AB	18 13.8 -21 04	3.85 10.5	258.5	16.81	2008.719	2	+0.5	-0.1	84*
BU 292AC		3.85 13.5	119.3	25.50	2008.719	2	+0.3	-	
HJ 2822AD		3.85 9.96	311.7	48.6	2008.719	2	-0.3	-0.1	
HJ 2822AE		3.85 9.22	14.7	50.4	2008.719	2	-0.2	-0.3	
I 1020	18 16.4 -40 28	8.20 7.97	274.6	0.41	2008.730	1	-0.7	-0.03	85
BU 760AC	18 17.6 -36 46	3.3 13.1	319.8	28.28	2008.719	1	-1.2	+0.14	86*
BU 760AD		3.3 10.4	318.1	93.1	2008.719	1	-0.9	+0.2	
SHJ 263AB	18 17.9 -18 48	6.75 9.25	11.5	54.0	2008.719	1	+0.1	+0.2	87
DUN 220	18 22.2 -55 34	8.07 8.45	176.9	31.3	2008.746	1	-0.1	+0.05	88
AC 11	18 25.0 -01 35	6.71 7.21	355.6 355.8	0.91 0.88	2008.727 2008.743	2 1	~0 +0.2	+0.03 ~0	89
STF2316AB	18 27.2 +00 12	5.38 7.62	320.1	3.72	2008.727	1	+0.1	-0.08	90
DUN 222	18 33.4 -38 44	5.58 6.16	358.5	21.42	2008.730	1	+0.2	+0.04	91
COO 227AB	18 43.8 -38 19	5.12 10.0	214.1	29.33	2008.730	1	~0	+0.1	92
COO 227AC		5.12 >10	50.9	43.26	2008.730	1	-0.4	~0	
STF2375AB	18 45.5 +05 30	6.34 6.73	120.1	2.56	2008.743	1	+0.6	+0.04	93
STF2417AB	18 56.2 +04 12	4.59 4.93	103.9 103.9	22.52 22.50	2008.727 2008.743	1 1	+0.2 +0.2	- -	94
BSO 14	19 01.1 -37 04	6.33 6.58	280.2	12.92	2008.743	1	-	-	95
HDO 150AB-C	19 02.6 -29 53	2.60 10.6	301.5	72.6	2008.719	1	-0.1	-0.1	96
HJ 5084	19 06.4 -37 04	4.53 6.42	18.7	1.34	2008.730	1	~0	~0	97
HJ 5092	19 13.9 -47 22	8.06 8.35	350.3	17.86	2008.746	1	+0.1	+0.13	98
GLE 3	19 17.2 -66 40	6.12 6.42	337.9	0.48	2008.743	1	-1.8	-0.04	99
BU 142	19 28.2 -12 09	8.12 8.69	276.0	0.94	2008.746	1	+0.1	~0	100
DUN 227	19 52.6 -54 58	5.80 6.39	148.0	23.0	2008.746	1	-0.4	+0.01	101
HDO 294	20 01.2 -38 35	8.08 9.11	28.7	1.18	2008.730	1	-0.9	-0.01	102
HJ 607AC	20 17.6 -12 30	4.24 9.6	222.6	46.7	2008.724	1	-	-0.2	103
DUN 230	20 17.8 -40 11	7.42 7.72	117.7	9.69	2008.730	1	+0.7	~0	104
HJ 608AB	20 18.1 -12 33	3.8 11.2	186.7	6.14	2008.724	1	-	-	105
HJ 608AC		3.8 11.5	195.3	6.84	2008.724	1	-	-	
AGC 12BC		11.2 11.5	245.4	1.20	2008.724	1	+2.4	-0.02	
R 321	20 26.9 -37 24	6.58 8.09	129.0	1.53	2008.730	1	+1.1	-0.01	106
SHJ 323AB	20 28.9 -17 49	4.97 6.88	192.4	1.46	2008.724	1	+2.0	-0.10	107
BU 61AC		4.9 13.2	150.0	54.6	2008.724	1	~0	+0.05	
SHJ 324	20 29.9 -18 35	5.91 6.68	238.6	21.96	2008.724	2	+0.4	+0.14	108
GLI 259AB	20 31.9 -40 54	8.44 8.44	157.7	4.18	2008.746	1	~0	~0	109*
I 1627AC		8.44 12.7	346.9	16.8	2008.746	1	-	-	
DUN 232	20 41.7 -75 21	6.51 7.07	18.6	16.72	2008.747	1	~0	+0.03	110
STF2729AB	20 51.4 -05 38	6.40 7.43	25.1	0.86	2008.743	1	-0.6	+0.07	111
RMK 26	20 51.6 -62 26	6.23 6.58	81.2 80.4	2.46 2.34	2008.743 2008.747	1 1	+0.2 -0.6	+0.09 -0.03	112
STF2744	21 03.1 +01 32	6.76 7.33	114.8	1.26	2008.749	1	+1.2	+0.02	113

Table continued on next page.

Double and Multiple Star Measurements at the Southern Sky with a 50cm-Cassegrain ...

Table 1 continued

PAIR	RA + DEC	MAGS	P.A. meas.	rho meas.	DATE	N	delta P.A.	delta rho	NOTES
HJ 5258	21 19.9 -53 27	4.50 6.93	270.0	7.24	2008.727	4	-1.0	+0.05	114
BU 766	21 24.4 -41 00	6.24 6.88	199.9	0.28	2008.746	1	-4	+0.03	115*
BU 1212AB	21 39.5 -00 03	6.94 8.44	283.8	0.48	2008.730	1	-1.0	-0.03	116*
			285.5	0.49	2008.749	1	+0.2	-0.02	
HU 5278	21 50.9 -82 43	5.56 7.26	62.5	3.48	2008.747	4	+0.8	~0	117
HDO 296	21 55.2 -61 53	6.6 6.8	105.0	0.38	2008.730	1	-0.1	+0.03	118
BU 276	22 00.8 -28 27	5.70 6.77	113.0 113.5	1.82 1.81	2008.724 2008.743	1 1	~0 +0.5	~0 -0.01	119
S 802AB	22 02.4 -16 58	7.22 7.15	246.8	3.85	2008.749	1	+0.4	~0	120
STF2862	22 07.1 +00 34	8.04 8.41	96.1	2.53	2008.749	1	+0.2	~0	121
BU 769Aa-B	22.11.6 -34 28	7.06 8.18	356.0	0.84	2008.727	1	-1.1	+0.02	122
HJ 5319	22 12.0 -38 18	7.65 7.66	313.9	2.07	2008.721	1	-0.1	-0.03	123
H N 56AB	22 14.3 -21 04	5.63 6.72	112.0	5.21	2008.749	4	+0.3	-	124*
SHJ 345AB	22 26.6 -16 45	6.29 6.39	34.7	1.34	2008.727	1	+0.7	+0.01	125
DUN 239	22 29.8 -43 45	4.33 9.71	210.0	60.6	2008.719	1	-0.8	+0.2	126
PZ 7	22 31.5 -32 21	4.28 7.12	171.7	30.4	2008.719	1	-0.3	+0.1	127
			172.5	30.4	2008.727	1	+0.5	+0.1	
I 304	22 46.8 -48 19	8.50 8.72	1.7	4.23	2008.719	1	-	-	128
STF2944AB	22 47.8 -04 14	7.30 7.68	298.7	1.98	2008.749	1	-0.5	+0.02	129*
STF2944AC		7.30 8.58	87.3	59.6	2008.749	1	-	-	
HJ 5367	22 52.5 -32 53	4.50 8.20	255.9	4.06	2008.724	1	-0.2	+0.02	130
HJ 5366	22 52.5 -42 47	8.46 9.40	251.5	14.80	2008.724	1	+0.2	-0.09	131
BU 178	22 55.2 -04 59	6.03 7.75	323.7	0.61	2008.749	1	+0.6	~0	132
I 22AB	22 55.3 -48 28	7.29 8.91	174.7	0.40	2008.719	1	~0	-0.01	133*
HWE 91	22 55.9 -32 32	4.2 9.2	248.9	4.91	2008.746	1	-	-	134
HJ 5371	22 57.8 -26 06	7.69 9.20	343.4	9.17	2008.746	1	+0.5	-0.01	135
JC 20AB	23 06.9 -43 31	4.45 6.60	112.5	1.50	2008.730	1	~0	-0.01	136
DUN 246	23 07.2 -50 41	6.29 7.05	254.5	8.89	2008.746	1	-0.1	+0.02	137
STF2988	23 12.0 -11 56	7.93 7.95	98.0	3.58	2008.749	1	-	-	138
RST5560AB	23 20.8 -50 18	6.15 8.93	233.5	1.35	2008.746	1	+1.3	+0.04	139
DUN 248AC		6.15 6.58	212.1	17.0	2008.746	1	+0.5	~0	
HU 295	23 22.7 -15 02	5.59 6.72	280.6	0.36	2008.730	1	+1.1	+0.02	140
STF3008	23 23.8 -08 28	7.21 7.67	150.0	6.40	2008.730	1	+1.0	+0.07	141
DUN 249	23 23.9 -53 49	6.14 7.07	212.1	26.47	2008.746	1	+0.2	-0.01	142
See 492	23 35.7 -27 29	6.48 9.18	14.3	0.59	2008.749	1	+3.3	+0.02	143*
BU 721AB-C	23 36.3 -07 07	8.60 8.77	133.6	0.30	2008.749	1	~0	-0.01	144
I 693	23 37.0 -36 48	8.04 9.21	88.5	1.41	2008.749	1	~0	~0	145
DUN 251	23 39.5 -46 38	6.53 7.27	277.7	3.86	2008.724	1	+0.7	-0.04	146
H 2 24	23 46.0 -18 41	5.65 6.46	135.4	6.94	2008.730	1	-	-	147
SLR 14	23 50.6 -51 42	8.28 8.59	73.1	0.84	2008.725	1	~0	-0.04	148
LAL 193	23 59.5 -26 31	8.05 8.30	169.7	10.6	2008.749	1	+0.2	+0.05	149

Table notes on next page.

Notes:

Terms relfix (relatively fixed), and cpm (common proper motion) refer to Burnham´s Celestial Handbook [9].

1. κ Sculptoris, P.A. decreasing.
2. in Sculptor.
3. β1 Tucanae, few data, C is b2, CD binary, P=44 y.
4. in Cetus, few data, AB very close binary, not resolved.
5. in Cetus, binary, P=25 y.
6. in Phoenix, P.A. slowly increasing.
7. λ Sculptoris, P.A. increasing.
8. in Phoenix, binary, P=516.5 y.
9. in Tucana, cpm, few data.
10. in Tucana
11. in Cetus, few data.
12. in Tucana, relfix, few data.
13. ζ Phoenicis, P.A. dec, rho slow inc.
14. in Phoenix, binary, P=80 y, few data. See fig. 3.
15. in Sculptor.
16. 42 Ceti, BC very close binary, not resolved.
17. in Cetus, binary, orbit uncertain.
18. in Eridanus, binary, P=250 y.
19. τ Sculptoris, binary, P~1503 y. See fig. 3.
20. p Eridani, binary, P=483.7 y.
21. in Cetus. P.A. is rapidly increasing, and rho rapidly decreasing, but an orbit of this very close pair has not yet been determined. It is not resolved here, but shows an elongated shape. Nevertheless, estimates of P.A. of 113 degrees and rho of 0.18" deviate from speckle data of about the same epoch by only 3.5 degrees and 0.02", respectively. See fig. 3.
22. ε (epsilon) Sculptoris, binary, "premature" orbit, P~1192 y, residuals against trend from speckle data, deviation from ephemeris.
23. in Hydrus.
24. in Cetus, binary, P=165 y. There is some confusion in the literature data on which is A, which B.
25. in Cetus, few data, last entry in WDS from1998, although termed relfix by Burnham, P.A. seems to slowly be decreasing, rho increasing, no residuals given.
26. 66 Ceti, few data with large scatter, no residuals given.
27. in Cetus, binary, P=173 y (?). Orbit uncertain, own measure is close to speckle data of about the same epoch, but both deviate from the ephemeris.
28. in Cetus, probably binary.
29. in Cetus, cpm, relfix.
30. in Cetus, relfix.
31. γ Ceti, P.A. inc, rho dec.
32. in Cetus, P.A. inc, rho dec (?), residuals against last entry in WDS.
33. in Cetus.
34. in Cetus, binary, P=114 y.
35. in Hydrus, optical, relfix, few data with large scatter, no residuals given.
36. 95 Ceti, binary, orbit uncertain, P=217...352 y (?).
37. in Reticulum, relfix.
38. in Reticulum, too few data, no residuals given.
39. θ Reticuli, few data.
40. in Dorado, P.A. inc, rho dec.
41. in Dorado, binary, P=240 y, orbit highly inclined, rho inc.
42. ι Pictoris, relfix, cpm, few data.
43. in Lepus, binary, P=54.8 y, residuals against ephemeris.
44. κ Leporis, although termed relfix by Burnham, P.A. and rho are decreasing.
45. 38 Leporis.
46. in Lepus, AB: P.A. decreasing, rho increasing. For AC only few data with large scatter, no residuals given.
47. θ Pictoris, few data with large scatter, no residuals given, AB close binary, not resolved.
48. in Columba, AB relfix, too few data, no residuals given, AC: P.A. and rho increasing.
49. in Lepus, few data.
50. in Dorado, probably binary, P.A. dec, rho inc.
51. β Leporis, large delta m, diffraction spikes used for measurements. P.A. increasing, rho decreasing until 1993, now increasing? Large residual of rho, reason unknown.

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Double and Multiple Star Measurements at the Southern Sky with a 50cm-Cassegrain ...

52. in Lepus, difficult, because of dim companion on diffraction ring, P.A. increasing, few data, no residuals given.
53. α Leporis, relfix, large delta m of AB and AC. For AC too few data, no residuals given. See fig. 7.
54. α Columbae, large delta m, P.A. dec, rho slow inc ? too few data, no residuals given. See fig. 6.
55. γ Leporis, large scatter of lit. data, no residuals given.
56. in Lepus, triple.
57. in Pictoris, few data, but relatively small scatter, rho inc.
58. in Lepus, P.A. slow dec ?
59. in Columba, AB relfix, AC P.A. inc, rho dec.
60. in Canis Maior, relfix.
61. ν Canis Maioris, relfix, color contrast, spectra F3-G. See fig. 8.
62. in Canis Maior, triple, few data with large scatter.
63. μ Canis Maioris, difficult, large delta m, large scatter of rho data, P.A. increasing, striking color contrast, spectra G5-A2. See fig. 8.
64. ε Canis Maioris, relfix, difficult, large delta m, few data, large scatter of rho data, no residual given. See fig. 6.
65. in Canis Maior, probably optical, striking color contrast, spectra K3-F0. See fig. 8.
66. also known as DUN 44, in Carina, few data, but relatively small scatter, P.A. inc, rho slow dec.
67. in Carina, PA & rho decreasing, few data, but relatively small scatter.
68. θ Carinae, few data.
69. υ Carinae, relfix, cpm, large delta m, few data with large scatter, P.A. inc.
70. α Centauri, binary, P=79.9 y.
71. α Circini, few data, but relatively small scatter, P.A. slow dec.
72. in Circinus, binary, P=288 y, residuals against recent speckle data.
73. in Norma, relfix, few data with large scatter, no residuals given.
74. in Triangulum Australe, cpm, PA & rho dec.
75. in Norma, relfix, few data, AC: PA inc, rho dec.
76. ε Normae.
77. in Triangulum Australe, optical, few data, but relatively small scatter, P.A. inc, rho dec.
78. in Ara, multiple, MLO 8 AB not resolved, too few data, no residuals given, in open cluster NGC 6193.
79. in Ara, binary, P=693 y (?), residuals given against WDS data of 2007, color contrast, spectra G8-M0. See fig. 8.
80. ι Arae, too few data, no residuals given.
81. γ (gamma) Arae, too few data, no residuals given, dim component "D" (>12 mag) at 39.4o/47.2" not listed in WDS. See fig. 7.
82. in Corona Australis, binary, P=191y.
83. in Sagittarius, P.A. dec, rho inc.
84. μ Sagittarii, multiple, few data, residuals somewhat uncertain, faint star (>13 mag) at 201.1o/25.5", not listed in WDS. See fig. 7.
85. in Corona Australis, relfix.
86. η Sagittarii, multiple, few data, AB not resolved because of large delta m at close distance, faint star (>13 mag) at 141.7o/19.7", not listed in WDS, several more, even fainter stars also in the field. See fig. 7.
87. in Sagittarius, few data with large scatter, rho dec ?
88. in Telescopium, relfix, P.A. dec ?, rho slow inc ?
89. in Serpens Cauda, binary, P=240 y, orbit highly inclined, large scatter of P.A. data in lit.
90. 59 Serpentis, large scatter of speckle data, P.A. slow inc.
91. κ Coronae Australis, relfix, few data.
92. λ Coronae Australis, triple, relfix, rho of AB and AC inc, P.A. of AC dec.
93. in Serpens Cauda, no significant change in the last 30 years.
94. in Serpens, relfix, residual of P.A. against speckle data, large scatter of rho data.
95. in Corona Australis.
96. ζ Sagittarii, AB not resolved because of large delta m at close distance, few data for AB-C, residuals against speckle data of 1991.
97. γ Coronae Australis, binary, P=121.8 y.
98. in Telescopium, few data, large deviation of rho from recent literature data, reason un-

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known.

99. in Pavo, binary, P=157 y, residuals against recent speckle data.
100. in Sagittarius, binary, P=162 y, own measures agree well with recent speckle data at about the same epoch, but both deviate from ephemeris.
101. in Telescopium, cpm, relfix, P.A. dec.
102. in Sagittarius, binary, P=475 y (?), ephemeris uncertain, because being based on only a small section of the orbit.
103. α^1 Capricorni, large scatter of literature data for P.A., no residual given.
104. in Sagittarius, few data, P.A. inc.
105. α^2 Capricorni. A close pair of dim companions is passing by the bright main star. Too few data, no residuals given. This triple has also been measured in 2008 with a 40 cm Cassegrain [4]. The present results are thought to be more accurate, because of better reference to the position of component A.
106. in Sagittarius, binary, P=178 y.
107. ρ Capricorni, AB binary, P=278 y, last speckle data from 2004, residuals against ephemeris. Separation tends to increase slower than expected.
108. o Capricorni, cpm, relfix.
109. in Microscopium, AB cpm, although few data, extrapolation appears trustworthy; C is an optical background star, relative position strongly changes, because of proper motion of AB with ~0.14 mas/y. See fig. 7.
110. μ^2 Octantis, cpm, P.A. inc, rho dec.
111. 4 Aquarii, binary, P=187 y.
112. in Pavo, also known as L 8550, cpm, relfix, P.A. dec.
113. in Aquarius, binary, “premature orbit”, P=1532 y, own measure follows trend of speckle data, but all deviate from ephemeris.
114. θ Indi, P.A. slow dec, rho inc, color contrast, spectra A5-G (?). See fig. 8.
115. θ^2 Microscopii, P.A. and rho decreasing, binary nature not established, despite close distance. See fig. 3.
116. 24 Aquarii, binary, P=49 y, many speckle data with small scatter.
117. λ Octantis, P.A. decreasing, rho increasing, color contrast.
118. in Indus, binary, P=27.5 y.
119. η Piscis Austrini, relfix, P.A. is slowly decreasing.
120. 29 Aquarii, few data, relfix, P.A. slowly increasing.
121. in Aquarius, relfix, some scatter of literature data.
122. in Piscis Austrinus, few data.
123. in Grus, P.A. inc.
124. 41 Aquarii, large scatter of recent rho data, color contrast. See fig. 8.
125. 53 Aquarii, binary, P=3500 y. Despite this long period, P.A. is now rapidly increasing near periastron.
126. δ^2 Gruis, few data, rho almost unchanged since 1953.
127. in Grus, few data.
128. in Grus, few data with large scatter.
129. in Aquarius, AB binary, P=1160 y, residuals against speckle data. C probably optical, P.A. fast decreasing, rho fast increasing. See fig. 7.
130. γ Piscis Austrini, P.A. decreasing.
131. in Grus, relfix.
132. in Aquarius, binary, P=120 y, orbit highly inclined.
133. τ^2 Gruis, deemed as binary, but no orbit yet determined, no speckle data between 1995 and 2008, own measure compares well with recent speckle data of about the same epoch. See fig 3.
134. in Piscis Austrinus, large delta m, few data with large scatter, no residual given, P.A. increasing.
135. in Piscis Austrinus, relfix, P.A. decreasing ?
136. θ Gruis, cpm, P.A. and rho inc.
137. in Grus, P.A. decreasing, rho increasing.
138. in Aquarius, relfix, although easy pair, large scatter of literature data, no residuals given.
139. in Grus, triple, AB: P.A. dec, AC: P.A. and rho inc.
140. in Aquarius, binary, P=63.2 y.
141. in Aquarius, optical, P.A. dec, rho inc.
142. in Grus, relfix.
143. in Sculptor, binary, P=78 y, difficult, because of large delta m, and companion close to dif-

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fraction ring of main star. The pair was not resolved in speckle data of 2008. See fig. 3.

144. in Aquarius, P.A. slowly decreasing, rho increasing.

145. in Sculptor, P.A. and rho increasing.

146. θ Phoenicis, P.A. increasing.

147. 107 Aquarii, few data with relatively large scatter.

148. in Phoenix, binary, P=117 y, residuals against speckle data of 2008.

149. in Sculptor, few data, P.A. and rho slow dec.

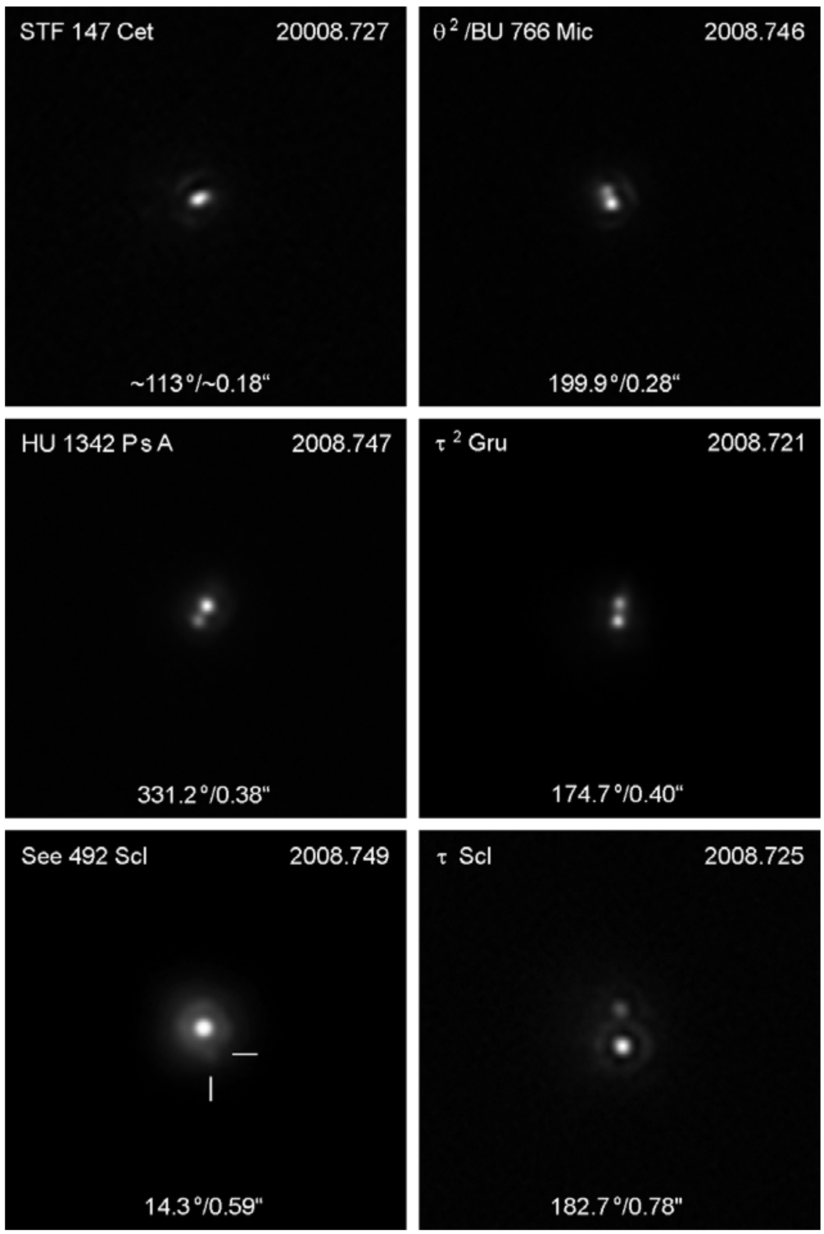

Figure 3: Some close pairs. The binary nature of STF 147, BU766 (top row), and tau Gruis (right, middle) has not yet been confirmed. The pair STF 147 is not resolved, but appears elongated. P.A. and rho are estimated. The pair See 492 (bottom left) is difficult to analyze, because of the proximity of the dim companion to the diffraction ring of the bright main star. All images are to scale. See also notes #21, 115, 14, 133, 143, and 19 (rows from top).

Double and Multiple Star Measurements at the Southern Sky with a 50cm-Cassegrain ...

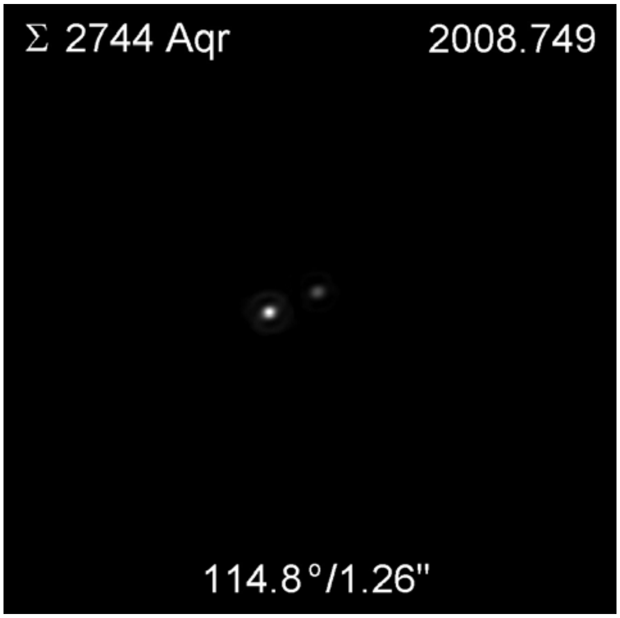

Figure 4: The binary STF 2744 in Aquarius.

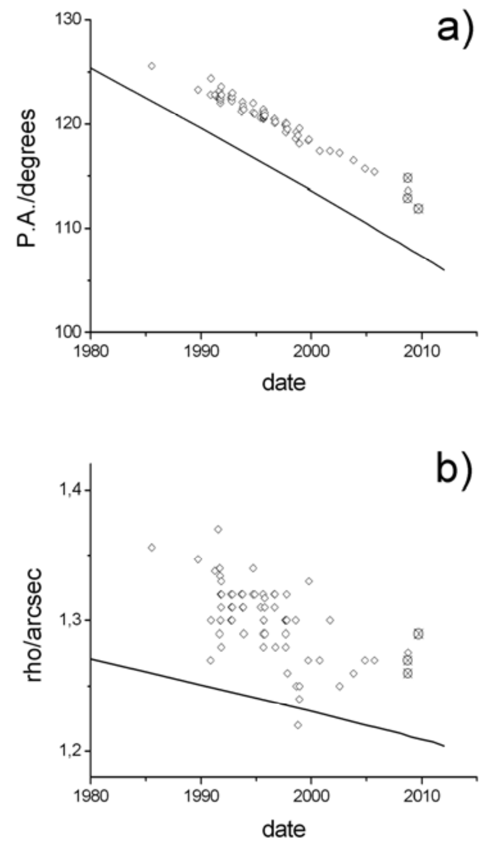

Figure 5: Plots of the position angle (a), and of the separation (a), respectively, versus date for STF 2744. Open rhombs are data from the speckle catalog, circles with crosses own measurements, one as reported here, and two more obtained in 2008 and 2009 with a 40 cm Cassegrain [4]. The lines are the ephemeris. See also note #113.

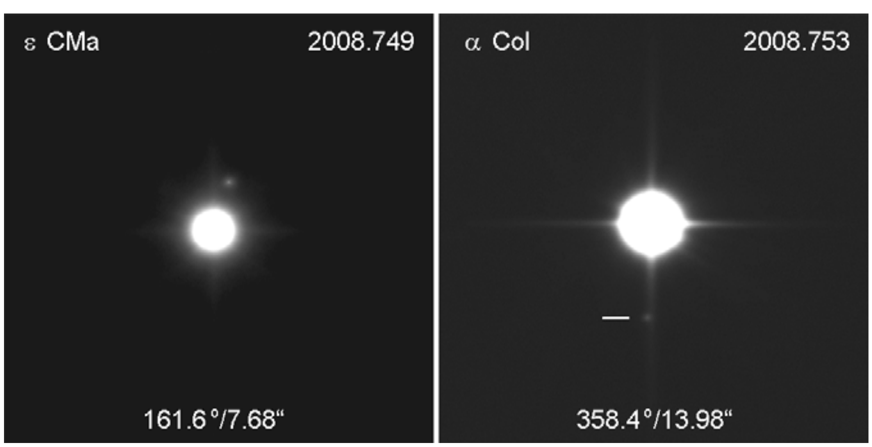

Figure 6: Two pairs with large delta m: 6 mag for epsilon CMa, and 10 mag for alpha Col. The centers of the diffraction spikes of the main stars were used to measure the positions of the companions. See also notes #64 and 54.

Double and Multiple Star Measurements at the Southern Sky with a 50cm-Cassegrain ...

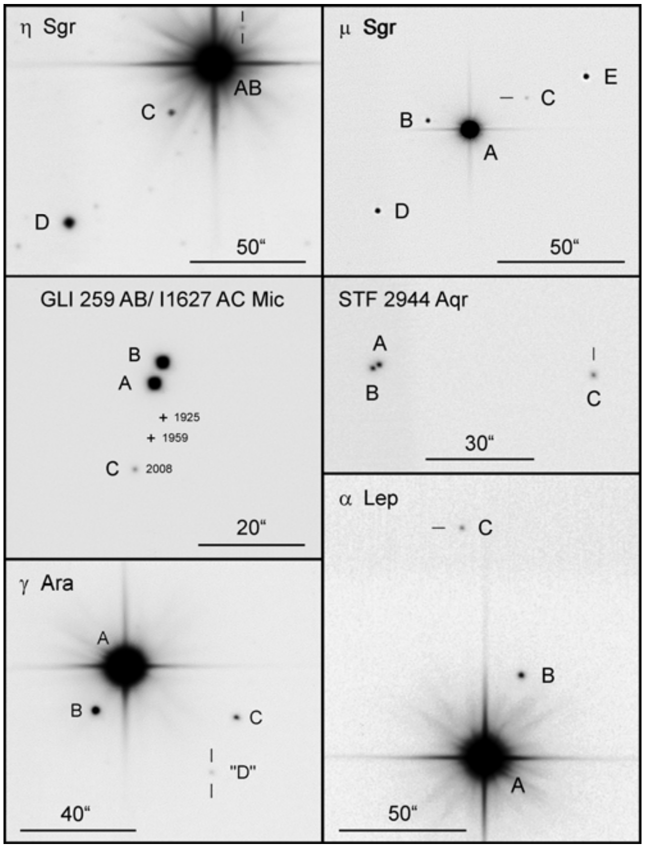

Figure 7: Some wide field images of multiples: The main star in the system η (eta) Sgr (top left) is a very close double, which is not resolved here. The faint star marked by lines is not listed in the WDS. GLI 259 AB (left, middle) is only about 155 Ly away, while the C component is a background star. Crosses mark the relative positions several decades ago, from which a proper motion of AB of 0.135 mas/y is deduced. The dim star "D" in γ (gamma) Arae (bottom left) is not listed in the WDS. Component C in STF 2944 (right, middle) is probably optical, as its relative position is fast changing. Images are not to scale. See also notes #86, 109, 81 (left column), and #84, 129, and 53 (right column).

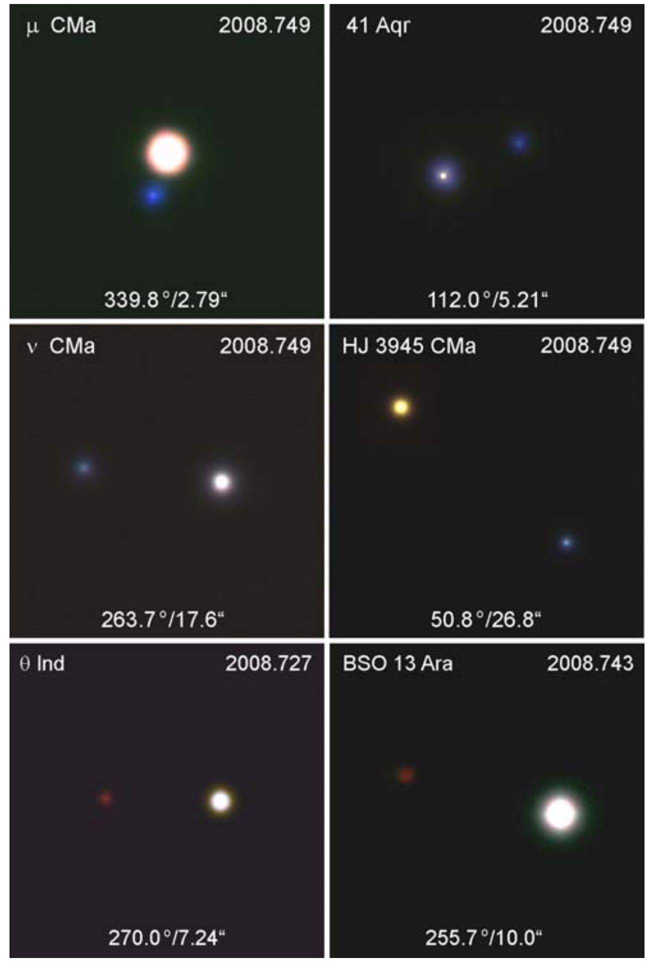

Figure 8: RGB-composites of colorful doubles. Companions are often bluer, but occasionally also redder than the main star. This is roughly reproduced here, but individual colors do not always correspond to the spectra of the components, because of imaging problems with large differences in brightness (see text). Likewise, reports by visual observers often strongly differ, due to personal variations of color perception, which also depends on brightness, and on contrast. See also notes #63, 124, 61, 65, 114, and 79 (rows from top to bottom).

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Concluding remarks

For many of the doubles investigated here there are only few data found in the literature, and often with large scatter. This includes even prominent members in their constellations. As systems, which exhibit only little change in the course of decades, or even centuries, may not seem to be of particular interest, they are often underobserved. More attention is given to binaries, be it confirmed or suspected, which are more or less regularly checked with speckle measurements. But even among these, there are cases, in which orbit calculations are still ambiguous, because of too long periods, and/or insufficient data. In particular, the following systems should be further monitored:

- Epsilon Sculptoris (see also note #22): An ephemeris has been calculated in 1969, but this is rather uncertain, as it is based on only a small fraction of the orbit. The current deviation of own as well as of extrapolated literature data is about 0.5 arcsec.

- HTG 1 in Cetus (note #27): Own measure of separation, as well as speckle data of about the same epoch deviate from ephemeris by 0.12 arcsec.

- β Leporis (note #51): Literature data show a virtually linear decrease of the separation since more than hundred years until 1993 (last entry in the WDS), which would extrapolate to about 2.15 arcsec at the epoch of my own measure of 2.6 arcsec. The reason for this large difference is unclear. More measurements should be done.

- AC 11 in Serpens Cauda (note #89): Own measure of separation as well as of recent speckle data are off from ephemeris by 0.07 arcsec, which almost certainly exceeds the error limits.

- HDO 294 in Sgr (note #102): Own measure and speckle data of about the same epoch deviate from ephemeris by almost 4 degrees (P.A.) and more than 0.08 arcsec (rho).

- ρ Capricorni (note #107): The separation seems to increase more slowly than expected from ephemeris. The actual deviation is greater than 0.1 arcsec.

- STF 2744 Aquarii (note #113, figs. 4 and 5): In accordance with recent speckle data, separation values are close to the ephemeris, while the position angle is systematically off by more than 4 degrees. Orbital motion appears to be slower than given by the calculations.

- BU 766 in Microscopium (note #115, and fig. 3): Since more than 100 years, P.A. and separation of this close pair are continuously decreasing, with rho now getting smaller than 0.3 arcsec, but orbital motion is still not obvious.

- τ^2 Gruis (note #133, and fig. 3): This close pair probably is a binary, but orbital motion is uncertain because of too few data.

- SEE 492 Sculptoris (note #143, and fig. 3): While own measurements closely follow the trend of earlier speckle data, and also roughly the ephemeris, the pair was not resolved in recent speckles in 2008, probably because of the large difference in brightness at close distance of the components.

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