Double Star Measurements at the Southern Sky with a 40 cm Cassegrain and a Fast CCD Camera in 2010

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Abstract: Using a 40 cm Cassegrain in Namibia, recordings of double stars were made with a fast CCD camera and a notebook computer. From superpositions of “lucky images,” measurements of 66 systems with 85 pairs were obtained and compared with literature data. Occasional deviations are discussed. Black-and-white 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 significantly be 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 this paper, measurements on double and multiple systems made in fall 2010 are reported. Star brightness is mostly greater than magnitude 8, and only a few dimmer companions go down to around magnitude 12. While in the majority of cases, literature data are scarce or exhibit large scatter, 8 pairs with sufficiently well documented separations could be used to verify the calibration. About 33 pairs are binaries with more or less well known orbits. In some cases, deviations from ephemeris data were found, and possible causes are discussed.

Instruments

The telescope is of Cassegrain type with aperture 40 cm and focal length of 6.3 m. It is located on a guest farm in Namibia and owned by the *Internationale Amateur-Sternwarte* (IAS) [1]. It is the same telescope which I have already used in 2008 and 2009, and results of measurements have been reported in this journal [2]. I only replaced the former DMK21AF04 camera by the type DMK31AF03 (*The Imaging Source*). While both use b/w-CCD´s, the main difference is the number and size of the pixels, 1024 x 768 of 4.65 µm square for type 31 instead of 640 x 480 of 5.6 µm for type 21, resulting in a correspondingly increased resolution of 0.155 arcsec/pix, or 0.0805 arcsec/pix with a nominally 2x Barlow lens. These values were both calculated from the scaling factors obtained in the previous work, and from the ratio of the pixel sizes, and were as well verified by calibration stars in this work (see below).

Position angles are measured as usual against trails in east-west direction, which are recorded while temporarily switching off the telescope drive.

Generally, I used a red or near infrared filter to reduce seeing effects and the atmospheric spectrum, and especially when using the Barlow lens, to reduce chromatic aberration. A few systems with color contrast were in addition recorded with green and blue filters in order to produce RGB composite images. 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 yield of “lucky” frames ranged from only a few percent to more than ten, depending on the seeing. The best

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frames were selected, re-sampled, registered, and stacked, mostly with automatic programs, in critical cases also manually. This process resulted in smooth intensity profiles and in position measurements with sub-pixel accuracy. More details of the technique and image processing are, for example, described in reference [3].

Results

All measurements are listed in Table 1, which is followed by individual notes. Numbering of the notes (last column at right) is with rounded R.A. values, which may make locating in the listings easier. Names, position, and magnitude data are taken from the *WDS* [4]. Several systems were recorded repeatedly, with or without Barlow, or with different filters. Measures of the position angle, P.A., and of the separation, ρ, were then averaged. N is the total number of recordings. Shaded lines denote systems which were used for calibration of the image scale (see below). The residuals, Δ P.A. and Δρ, refer to the trends of literature data, if sufficiently available, or for binaries, to the currently assumed ephemeris. Main sources are the *Fourth Catalog of Interferometric Measurements of Binary Stars ("speckle catalog")* [5], and the *Sixth Catalog of Orbits of Visual Binary Stars* [6]. Data available up to fall 2013 are taken into account, as of writing this article. In several cases, larger deviations were found, which often agree with trends of literature data, however. These will be discussed in more detail below. In other cases, literature data are so scarce and/or exhibit so large scatter that no reasonable residuals can be given.

Discussion

In Table 1, systems used for calibration of the image scale are marked with shaded lines, and comprise both measurements with and without Barlow. In Figures 1 and 2, individual residuals are plotted separately, partly to demonstrate that the calibration constants for both modes, as given above in the section *Instruments*, are consistent. In fact, the ratios of both constants referred to those obtained earlier with the DMK21 camera (0.830) correspond virtually exactly to the ratio of the nominal pixel sizes of both cameras (0.8304). The ratio of the constants with and without the nominally 2x Barlow is 1.925.

Generally, and according to earlier work, error margins for separation measurements are expected to be of the order of ±0.02 arcsec, and not to exceed ±0.05 arcsec, at least in the range of small separations. As can be seen in Figure 1, several pairs are clearly off, and interestingly, these are mostly binaries. It seems that one reason is that the residuals are calculated with respect to the current ephemeris, which may not be up to date. In fact, in many cases, residuals against the trend of recent measurements are found to be smaller.

The error margins of measurements of the position angle are expected to be of the order of about ±0.2 degrees for large separations, but to increase toward small separations, and can reach several degrees for very close pairs. The reason is the fixed resolution in the images. In fact, this is apparent in the plots in Figure 2. However, a number of pairs seem to stand out more

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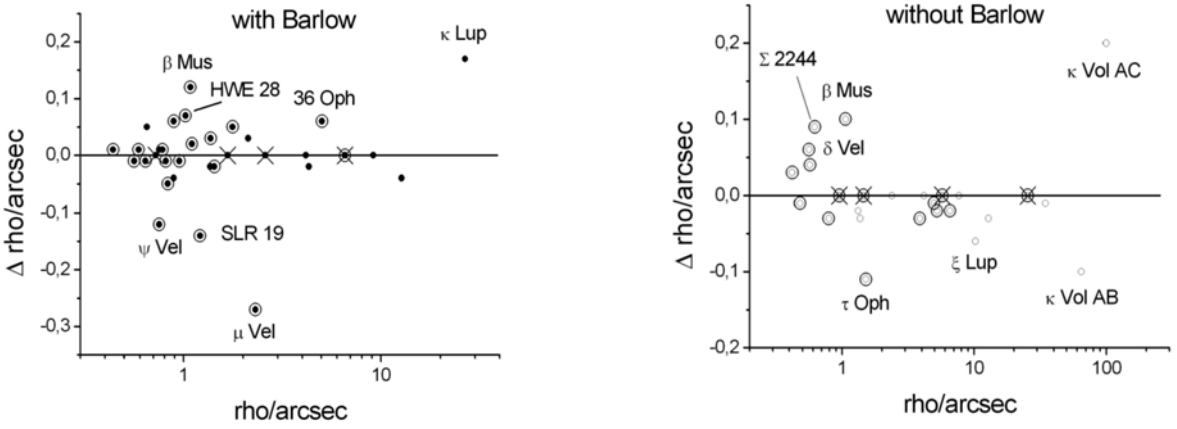

Figure 1: Plots of the residuals of rho versus rho. Semi-logarithmic scale. With Barlow (Left) and without. Symbols with crosses denote systems used for calibration. Additional circles indicate binaries. Some systems with large deviations are marked with their names. See text.

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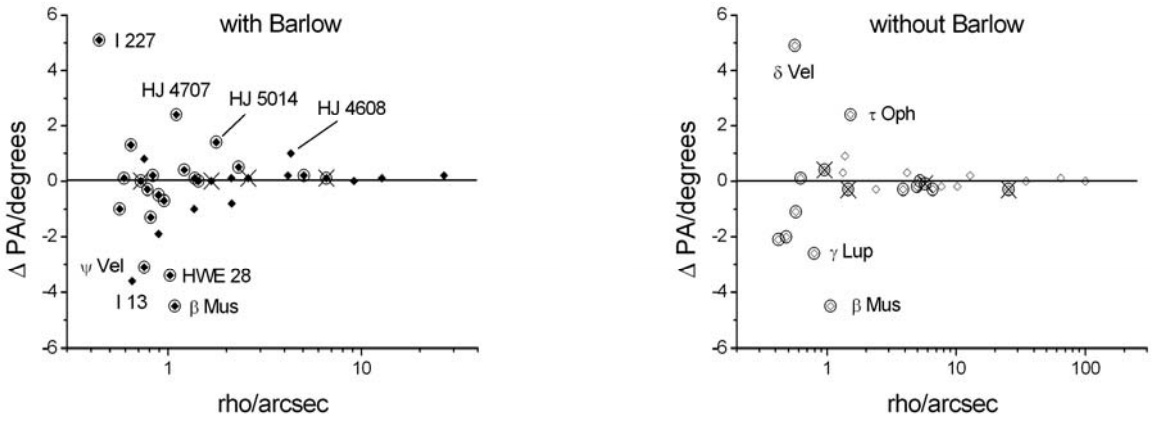

Figure 2: Plots of the residuals of the position angle versus rho. Semi-logarithmic scale. Left with Barlow, right without. The increase of scatter toward small separations is caused by scatter of literature data, as well as by the fixed image resolution. Calibration pairs are marked as in Figure 1. (They are not used for calibration of the position angle.)

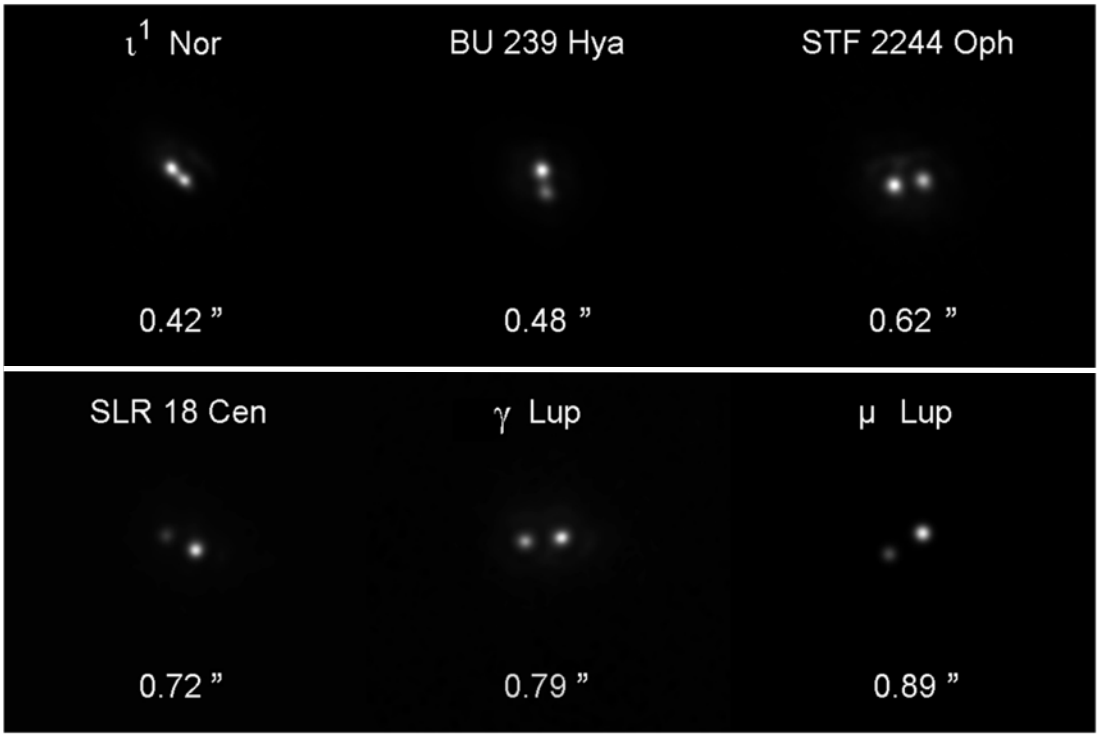

Figure 3: Some close doubles. Iota Normae is a binary with a rather short period of only 26.9 years. For BU 239 in Hydrus, less than a quarter of its assumed orbit is documented. The case of STF 2244 in Ophiuchus is further illustrated in Figure 4. Pairs SLR 18 in Centaurus and μ Lupi possibly are binaries, while γ Lupi is a binary with a period of 190 years

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Table 1: List of all measurements. Systems used for calibration of the image scale are marked by shaded lines. Position angles (P.A.) are in degrees, separations (rho) in arcseconds. N is the number of different recordings. Residuals delta P.A. and/or delta rho are given, when extrapolations of literature data appear reasonable. Data written in italics were obtained from recordings with Barlow, normal letters indicate no Barlow.

PAIR	RA + DEC	MAGS	P.A. meas.	rho meas.	DATE	N	delta P.A.	delta rho	NOTES
RMK 6	07 20.4 -52 19	6.00 6.51	*26.0*	*9.15*	*2010.297*	1	*~0*	*~0*	07 20
RMK 7	08 07.9 -68 37	4.38 7.31	23.1	6.03	2010.275	1	-1.0	-0.02	08 08
RMK 8	08 15.3 -62 55	5.27 7.62	69.1	4.05	2010.275	1	*	*	08 15
BSO 17AB	08 19.8 -71 31	5.31 5.59	58.1	64.66	2010.275	1	+0.1	-0.1	08 20
BSO 17AC		5.31 7.67	48.0	99.42		1	~0	+0.2	
BSO 17BC		5.59 7.67	30.4	37.51		1	-1.6	+0.8	
RMK 9AB	08 45.1 -58 43	6.87 6.93	292.3	4.15	2010.275	1	+0.3	~0	08 45
RMK 9AC		6.87 11.0	359.7	51.74		1	*	*	
RMK 9AD		6.87 10.8	222.7	60.50		1	*	*	
I 11	09 15.2 -45 33	6.56 7.65	*293.2*	*0.75*	*2010.295*	1	*+0.8*	*+0.01*	09 15
COP 1	09 30.7 -40 28	3.91 5.12	*99.5*	*0.75*	*2010.284*	1	*-3.1*	*-0.12*	09 31
SEE 115	09 37.2 -53 40	6.12 6.28	*8.8*	*0.69*	*2010.295*	1	*	*	09 37
RMK 11	09 47.1 -65 04	3.02 6.00	126.1	4.98	2010.275	1	*	*	09 47
I 173	10 06.2 -47 22	5.32 7.10	*6.4*	*0.95*	*2010.295*	1	*-0.7*	*-0.01*	10 06
I 13AB	10 09.5 -68 41	6.63 6.47	*103.7*	*0.65*	*2010.278*	1	*	*	10 10
HJ 4306	10 19.1 -64 41	6.26 6.48	*313.1*	*2.59*	*2010.278*	1	*+0.1*	*~0*	10 19
R 155	10 46.8 -49 25	2.82 5.65	*56.2*	*2.31*	*2010.295*	1	*+0.5*	*-0.27*	10 47
SEE 143	12 03.6 -39 01	7.05 7.65	35.0	0.57	2010.300	1	-1.1	+0.04	12 04
DUN 252AB	12 26.6 -63 06	1.25 1.55	111.9	3.92	2010.276	4	-0.1	+0.02	12 27
DUN 252AC	12 26.6 -63 06	1.25 4.80	203.7	89.9	2010.269	2	+0.3	*	12 27
ANT 1G	12 26.6 -63 06	1.25 12?	145.3	56.7	2010.269	2	*	*	12 27
ANT 1H	12 26.6 -63 06	1.25 13?	166.2	48.2	2010.269	1	*	*	12 27
ANT 1I	12 26.6 -63 06	1.25 12?	226.7	63.7	2010.269	1	*	*	12 27
Ax	12 26.6 -63 06	1.25 12?	343.6	29.6	2010.269	1	*	*	12 27
Ay	12 26.6 -63 06	1.25 13?	217.8	125.2	2010.269	1	*	*	12 27
DUN 124AB	12 26.6 -63 06	1.83 6.45	25.5	128.9	2010.269	1	*	*	12 27
DUN 124AC	12 26.6 -63 06	1.83 9.7	70.0	165.7	2010.269	1	*	*	12 27
STF1669AB	12 41.3 -13 01	5.88 5.89	312.8	5.22	2010.286	1	~0	-0.02	12 41
STF1670AB	12 41.7 -01 27	3.48 3.57	21.8	1.45	2010.295	2	-0.3	~0	12 42
R 207	12 46.3 -68 06	3 .52 3.98	48.3	1.07	2010.286	5	-4.5	+0.11	12 46
I 362AB	12 47.7 -59 41	1.28 11.4	326.2	42.62	2010.270	1	*	*	12 48
I 362AX	12 47.7 -59 41	1.28 ~11?	139.9	10.38	2010.270	1	*	*	12 48
I 362AY	12 47.7 -59 41	1.28 >11	213.1	29.58	2010.270	1	*	*	12 48
DUN 126AB	12 54.6 -57 11	3.94 4.95	17.2	34.70	2010.289	1	~0	-0.01	12 55

Table 1 continues on next page.

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Table 1 (continued): List of all measurements. Systems used for calibration of the image scale are marked by shaded lines. Position angles (P.A.) are in degrees, separations (rho) in arcseconds. N is the number of different recordings. Residuals delta P.A. and/or delta rho are given, when extrapolations of literature data appear reasonable. Data written in italics were obtained from recordings with Barlow, normal letters indicate no Barlow.

PAIR	RA + DEC	MAGS	P.A. meas.	rho meas.	DATE	N	delta P.A.	delta rho	NOTES
I 83	12 56.7 -47 41	7.39 7.68	*233.5*	*0.83*	*2010.273*	*1*	*+0.2*	*-0.05*	12 57
R 213	13 07.4 -59 52	6.59 7.04	*21.1*	*0.69*	*2010.273*	1	*	*	13 07
SLR 18	13 22.9 -47 45	6.73 7.18	*242.9*	*0.72*	*2010.273*	1	*~0*	*~0*	13 23
DUN 141		5.20 6.53	*162.9*	*5.64*		4	*+0.1*	*+0.06*	
HJ 4608	13 41.7 -54 34	7.42 7.47	*188.9*	*4.31*	*2010.273*	1	*+1.0*	*-0.02*	13 41
HWE 95		7.51 7.85	*184.8*	*0.95*		1	*	*	
HWE 28AB		6.27 6.38	*312.7*	*1.02*		1	*-3.4*	*+0.07*	
SLR 19	13 53.5 -35 40	7.14 7.38	*322.8*	*1.21*	*2010.273*	1	*+0.4*	*-0.14*	13 53
HWE 75AB		7.96 8.60	*214.5*	*4.16*		1	*+0.2*	*~0*	
RHD 1AB	14 39.6 -60 50	0.14 1.24	246.6	6.58	2010.279	3	-0.1	~0	14 40
HJ 4707	14 54.2 -66 25	7.53 8.09	*275.8*	*1.10*	*2010.295*	1	*+2.4*	*+0.02*	14 54
I 227AB	14 56.5 -34 38	8.06 8.39	*105.7*	*0.44*	*2010.285*	2	*+5.1*	*+0.01*	14 56
HJ 4715	14 56.5 -47 53	5.98 6.82	*277.9*	*2.12*	*2010.275*	1	*+0.1*	*+0.03*	14 57
H N 28AB	14 57.5 -21 25	5.88 8.18	306.2	25.43	2010.292	1	-0.3	~0	14 58
BU 239AB	14 58.7 -27 39	6.17 6.79	7.9	0.48	2010.292	2	-2.0	~0	14 59
HJ 4728AB	15 05.1 -47 03	4.56 4.60	*65.0*	*1.67*	*2010.273*	1	*~0*	*~0*	15 05
DUN 177	15 11.9 -48 44	3.83 5.52	*142.9*	*26.68*	*2010.275*	1	*	*	15 12
STF3091AB	15 16.0 -04 54	7.74 8.48	*224.9*	*0.56*	*2010.296*	1	*-1.0*	*-0.01*	15 16
HJ 4753AB	15 18.5 -47 53	4.99 4.93	*302.4*	*0.89*	2010.275	1	*-1.9*	*-0.04*	15 19
DUN 180AC	15 18.5 -47 53	4.99 6.34	*129.1*	*23.18*	*2010.275*	1	*	*	15 19
DUN 180BC	15 18.5 -47 53	4.93 6.34	*128.9*	*24.07*	*2010.275*	1	*	*	15 19
HJ 4786	15 35.1 -41 10	2.95 4.45	274.8	0.79	2010.278	3	-2.2	-0.03	15 35
HJ 4788	15 35.1 -41 10	4.68 6.51	*10.3*	*2.13*	2010.278	1	*-0.8*	*+0.08*	15 35
PZ 4	15 35.1 -41 10	5.09 5.56	49.1	10.18	2010.278	1	*	*	15 35
RMK 21AB	16 00.1 -38 24	3.37 7.50	19.0	15.14	2010.275	1	*	*	16 00
SEE 258AB	16 00.1 -38 24	5.20 5.76	227.9	0.42	2010.275	2	-2.1	+0.03	16 00
HJ 4825AB-C	16 00.1 -38 24	4.64 8.02	242.6	11.07	2010.275	2	+1.6	-0.13	16 00
STF1998AB	16 04.4 -11 22	5.16 4.87	355.8	0.95	2010.277	2	+0.4	~0	16 04
STF1998AC	16 04.4 -11 22	5.16 7.30	42.2	7.92	2010.277	2	*	*	16 04
STF1998BC	16 04.4 -11 22	4.87 7.30	46.8	7.30	2010.277	2	*	*	16 04
BSO 11	16 09.5 -32 39	6.70 7.23	84.0	7.65	2010.300	1	-0.2	~0	16 10
BU 120AB	16 12.0 -19 28	4.35 5.31	1.5	1.32	2010.299	2	-0.9	-0.02	16 12
H 5 6AC	16 12.0 -19 28	4.35 6.60	335.9	41.56	2010.299	2	*	*	16 12
MTL 2CD	16 12.0 -19 28	6.60 7.23	56.4	2.36	2010.299	2	+0.8	+0.01	16 12

Table 1 concludes on next page.

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Table 1 (conclusion): List of all measurements. Systems used for calibration of the image scale are marked by shaded lines. Position angles (P.A.) are in degrees, separations (rho) in arcseconds. N is the number of different recordings. Residuals delta P.A. and/or delta rho are given, when extrapolations of literature data appear reasonable. Data written in italics were obtained from recordings with Barlow, normal letters indicate no Barlow.

PAIR	RA + DEC	MAGS	P.A. meas.	rho meas.	DATE	N	delta P.A.	delta rho	NOTES
SH 224Aa-B	16 21.2 -25 36	2.89 8.42	273.0	19.97	2010.297	1	*	*	16 21
STF2055AB	16 30.9 +01 59	4.15 5.15	*37.2*	*1.43*	*2010.296*	1	*~0*	*-0.02*	16 31
BU 1118AB	17 10.4 -15 44	3.05 3.27	*235.2*	*0.59*	*2010.279*	1	*+0.1*	*+0.01*	17 10
SHJ 243AB		5.12 5.12	142.6	5.00		2	~0	+0.03	
H 3 25	17 15.3 -26 36	5.23 6.64	354.1	9.98	2010.277	1	*	*	17 15
MLO 4AB		6.37 7.38	*185.4*	*1.33*		1	*-0.9*	*-0.05*	
STF2173		6.06 6.17	*154.9*	*0.78*		1	*-0.3*	*+0.01*	
STF2244	17 30.4 -01 04	6.89 6.56	280.2	0.62	*2010.279*	1	+0.1	+0.09	17 30
STF2262AB		5.27 5.86	287.3	1.51		1	+2.4	-0.11	
STF2272AB	18 05.5 +02 30	4.22 6.17	131.0	5.73	2010.274	1	-0.1	~0	18 05
HJ 5014	18 06.8 -43 25	5.65 5.68	*3.6*	*1.77*	*2010.275*	1	*+1.4*	*+0.05*	18 07
STF2281AB	18 09.6 +04 00	5.97 7.52	*287.9*	*0.64*	*2010.296*	1	*+1.1*	*-0.01*	18 10
BU 132AB	18 11.2 -19 51	7.01 7.13	188.9	1.37	2010.293	1	+0.9	-0.03	18 11
BU 760AB	18 17.6 -36 46	3.30 8.0	99.9	3.55	2010.297	1	*	*	18 18
BU 760AD	18 17.6 -36 46	3.30 10.0	318.2	93.8	2010.297	1	*	*	18 18
AC 11	18 25.0 -01 35	6.71 7.21	*354.2*	*0.89*	*2010.296*	1	*-0.5*	*+0.06*	18 25
DUN 222	18 33.4 -38 44	5.58 6.16	358.4	21.19	2010.278	1	~0	-0.15	18 33
BSO 14	19 01.1 -37 04	6.33 6.58	280.6	12.77	*2010.279*	2	+0.2	-0.03	19 01
HJ 5084	19 06.4 -37 04	4.53 6.42	*11.1*	*1.37*	*2010.277*	2	*+0.1*	*+0.03*	19 06

Notes:
Terms “cpm” (common proper motion) and "relfix" (relatively fixed) refer to Burnham [7].

07 20: also known as DUN 44, in Carina, few data, position about constant in recent decades.
08 08: ε Volantis, relfix, cpm, few data.
08 15: also known as c Carinae, relfix, cpm, few data, PA & rho seem to slowly increase.
08 20: $\kappa^{1,2}$ Volantis, wide triple, few data with large scatter.
08 45: in Carina, relfix, few data.
09 15: in Vela, PA increasing, rho decreasing.
09 31: ψ Velorum, binary, P = 34 y, the complete orbit is covered by visual measurements, but there are much less speckle data. Own measures deviate from ephemeris, but seem to be in line with recent speckle data. Rho is currently rapidly increasing.
09 37: in Vela, PA & rho increasing.
09 47: υ Carinae, relfix, cpm, few data, large scatter.
10 06: in Vela, binary, P = 232 y, own measures are close to recent speckle data, as well as to the revised ephemeris (Scardia 2008e).
10 10: in Carina, PA & rho decreasing, few data.
10 19: in Carina, “relfix”, PA decreasing, rho increasing, few data.
10 47: μ Velorum, binary, P = 138 y, few data, own measure of rho as well as recent speckle data significantly deviate from ephemeris.
12 04: also known as 89 Centauri, binary, P = 109 y, own measure of rho slightly deviates from orbit, in line with recent speckle measurements.
12 27: α Crucis, AB binary, no orbit determined, few data, even fewer for AC. Dim components G, H, and I have been observed already in 2007. Positions virtually did not change since then. Two other dim stars in the field are not listed in WDS. See fig. 6.
12 31: γ Crucis, optical triangle, few data. A fourth dim star is not listed in the WDS. See fig. 6.
12 41: in Corvus, binary, P = 4500 y estimated, rho data exhibit large scatter.

12 42: γ Virginis, binary, P =169 y, well documented.
12 46: β Muscae, binary, P = 383 y, while own measures of both PA and rho deviate from the recently re-calculated ephemeris, the position is close to the corresponding orbit.
12 48: β Crucis, optical?, few data. Dim companions X and Y are not listed in WDS. See fig. 6.
12 55: μ Crucis, relfix.
12 57: in Centaurus, binary, P = 294 y, position slightly deviates from ephemeris, but seems to better fit recent speckle data.
13 07: in Centaurus, relfix, PA decreasing, own measure seems to follow the long time trend, despite large scatter of recent speckle data, rho decreasing since about 1950.
13 23: in Centaurus, PA and rho increasing, reasonable extrapolation. See fig. 3.
13 41: in Centaurus, relfix, few data.
13 42: in Centaurus, few data, PA slowly increasing, rho data exhibit considerable scatter.
13 44: in Centaurus, few data, PA and rho decreasing.
13 53: in Centaurus, binary, P = 258 y, measured position deviates from ephemeris, but is in line with recent speckle data.
14 08: in Centaurus, binary, P = 233 y, measured position deviates from ephemeris, but seems to follow the trend of recent speckle data.
14 37: in Centaurus, relfix, few data.
14 40: α Centauri, AB binary, P = 79.9 y, well documented.
14 54: in Circinus, binary, P = 288 y, few data since 2000.
14 56: in Centaurus, binary, P = 40 y, few data, large residuals vs. ephemeris, own measures close to trend of literature data.
14 57: also known as DUN 174, in Lupus, although denoted as relfix by Burnham, rho has decreased since 1826, while the PA stays about constant in the last hundred years.
14 58: also known as 33 Librae, AB binary, P = 2130 y (?), only small portion of orbit documented.
14 59: also known as 59 Hydrae, binary, P = 429 y. See fig. 3.
15 05: π Lupi, PA decreasing, reasonable extrapolation.
15 12: κ Lupi, relfix, cpm, few data with large scatter. Extrapolation ambiguous.
15 16: in Libra, binary, P = 156 y.
15 19: μ Lupi, triple, all cpm, AB: PA & rho decreasing, AC: few data. See fig. 3.
15 35: γ Lupi, binary, P = 190 y, orbit highly inclined. See fig. 3.
15 36: also known as d Lupi, few data, PA & rho decreasing.
15 57: ξ Lupi, relfix, although a wide and easy pair, large scatter of literature data.
16 00: η Lupi, relfix, cpm, few data, large scatter.
16 03: ι^1 Normae, triple, all cpm, AB binary, P = 26.9 y, few data. See fig. 3.
16 04: ξ Scorpii, triple, AB: binary, P = 45.8 y, many speckle data. AC: few data, large scatter, own measures significantly deviate from ephemeris, but are close to recent speckle data.
16 10: also known as L 6706, in Scorpius, cpm, few data.
16 12: ν Scorpii, “double-double”, rho(AB) slowly increasing, PA(CD) slowly increasing, few data for AC.
16 21: σ Scorpii, Aa not resolved.
16 31: λ Ophiuchi, binary, P = 130 y.
17 10: η Ophiuchi, binary, P = 88 y, many speckle data with mostly small scatter.
17 15: also known as 36 Ophiuchi, binary, P = 550 y (?),”premature orbit”, although an easy pair, large scatter of recent data in the literature.
17 18: ο (39) Ophiuchi, relfix, cpm, few data.
17 19: in Scorpius, binary, P = 42.1 y.
17 30: in Ophiuchus, binary, P = 46.4 y, highly inclined orbit.
17 57: in Ophiuchus, binary, P = 280 y, highly inclined orbit, recent rho data (speckle as well as own) extend way off the ephemeris, while PA measures are close. See fig. 3.
18 03: τ (69) Ophiuchi, binary, P = 280 y, many speckle data, PA data exhibit peculiar variations at around 1997, 2003, and 2010. Own measures deviate from ephemeris, but seem to follow literature data.
18 05: also known as 70 Ophiuchi, binary, P = 88.3 y, many speckle data with only little scatter.
18 07: in Corona Australis, binary, P = 191 y, own measures deviate from ephemeris, but are close to results obtained in 2009, and all seem to follow the trend of speckle data.
18 10: also known as 73 Ophiuchi, binary, P = 286 y, many speckle data with small scatter.
18 11: in Sagittarius, PA decreasing, rho increasing.
18 18: η Sagittarii, triple, few data.
18 25: in Serpens Cauda, binary, P = 240 y, highly inclined orbit, own measure of rho significantly deviates from ephemeris, but fits well to recent speckle data.
18 33: κ Coronae Australis, relfix, few data.
19 01: in Corona Australis, relfix, cpm.
19 06: γ Coronae Australis, binary, P = 122 y.

Double Star Measurements at the Southern Sky with a 40 cm Cassegrain and a Fast CCD Camera in 2010

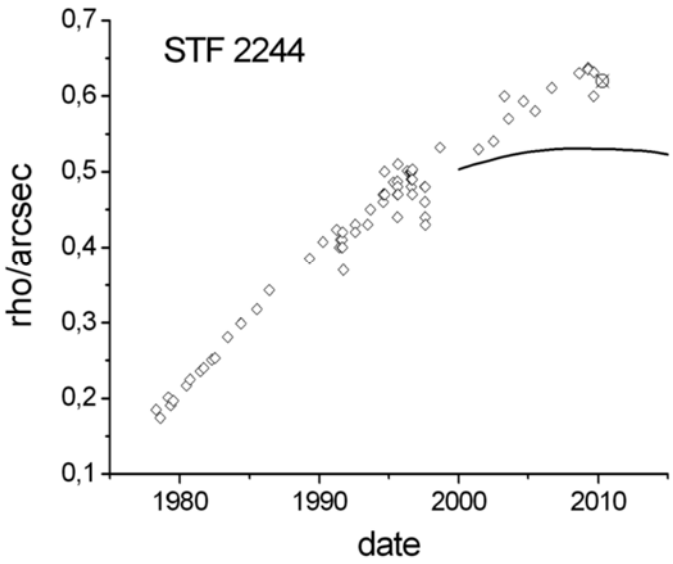

Figure. 4: Separation vs. time for STF 2244 in Ophiuchus. Open rhombi are speckle data [5], the crossed circle own measurement, and the curve represents part of the ephemeris [6]. See text.

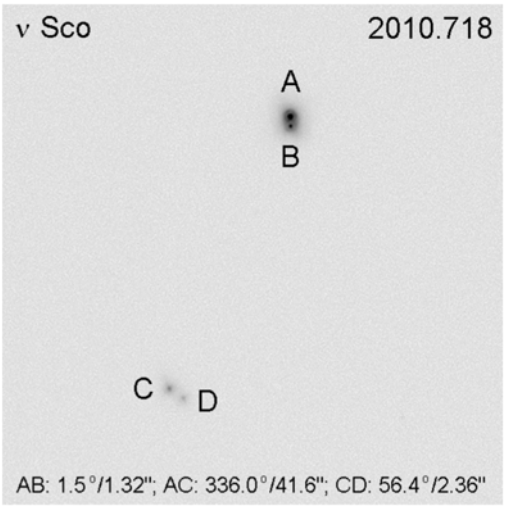

Figure 5: The "double-double" ν Scorpii. In contrast to famous ε Lyrae, orbital motion has not yet been confirmed for neither AB nor CD.

(Continued from page 126)

than this, and again, most are binaries.

Possible origins of deviations of PA and rho are already mentioned in the notes list. In particular, the following binaries deserve further attention in the (near and far) future (in order of increasing R.A.):

- psi Velorum,
- I 13 AB in Carina,
- mu Velorum,
- beta Muscae,
- I 83 in Centaurus,
- SLR 19 in Centaurus,
- I 227 in Centaurus,
- xi Scorpii AC (triple),
- STF 2244 in Ophiuchus (see also figs. 3 and 4),
- tau (69) Ophiuchi,
- HJ 5014 in Corona Australis,
- AC 11 in Serpens Cauda.

Some images of double and multiple systems are presented in the following figures. Figure 3 is a selection of close binaries with sub-arcsec separations. For one of these, STF 2244, recent separation measurements are plotted in Figure 4 and compared with the currently assumed ephemeris. While my own measure follows the trend of speckle data, the deviation from the ephemeris clearly exceeds the error margins. Figures 5 and 6 illustrate interesting multiple systems, in particular with large differences in brightness (Fig. 6). In all images, north is down, and east is right.

Conclusion

For many of the doubles investigated here there are only few data found in the literature, and often with large scatter, although most systems are fairly bright, and easily accessible. The accuracy of my own measurements is checked by comparing with mainly speckle data of systems, which have often been sufficiently observed. Generally, the scatter is of comparable magnitude. Similar to earlier work, this measuring campaign revealed several double star systems, which should more often be measured.

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[2] Anton, R., *Journal of Double Star Observations,* **6** 2, 133-140, 2010.

[3] Anton, R., "Lucky Imaging" in *Observing and Measuring Visual Double Stars, 2nd Ed.*, Robert Argyle, ed., Springer, New York, 2012.

Double Star Measurements at the Southern Sky with a 40 cm Cassegrain and a Fast CCD Camera in 2010

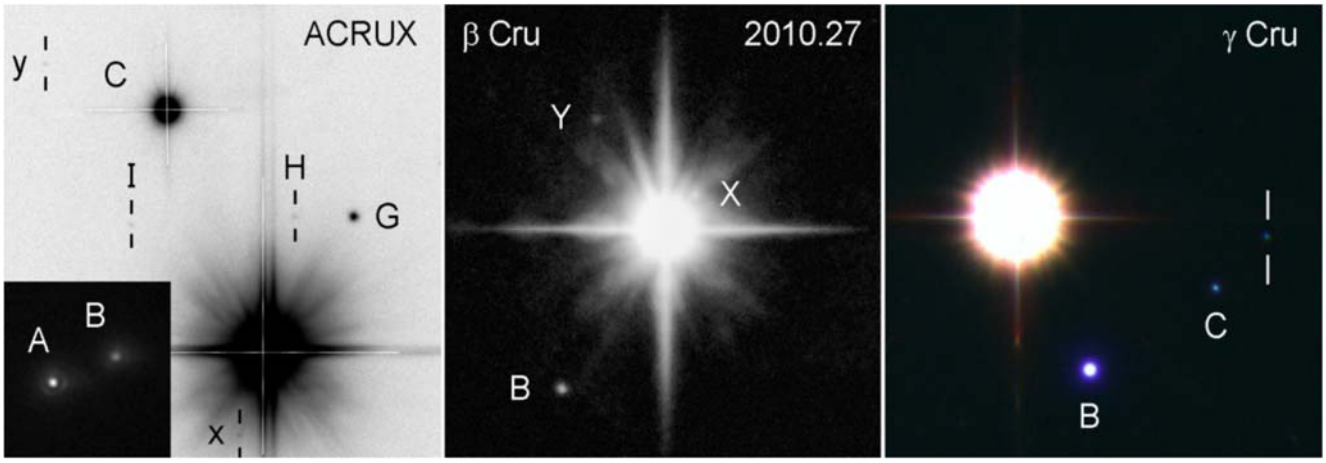

Figure 6: The three brightest stars in Crux. Left: alpha Crucis. The inset shows the pair AB recorded at higher magnification and with shorter exposure time. It is deemed as binary, but no valid orbit is listed in the catalogue. Two very weak stars (x and y) are not listed in the WDS. X was not seen in a similar image taken in 2007, while y was not in the field.

Middle: The pair beta Crucis AB probably is optical. The dim companions X and Y are not listed in the WDS.

Right: RGB composite of gamma Crucis, recorded with an 80/800 mm refractor, which is attached to the main scope, and normally used as a guidescope. In this wide field view, the main star of spectral class M3.5III forms an optical triangle with B and C. The dim star marked with white lines is not listed in the WDS.

[4] Mason, B.D. et al., *The Washington Double Star Catalog (WDS)*, U.S. Naval Observatory, online access Oct. 2013.

[5] Hartkopf, W.I. et al., *Fourth Catalog of Interferometric Measurements of Binary Stars,* U.S. Naval Observatory, online access Oct. 2013.

[6] Hartkopf, W.I. et al., *Sixth Catalog of Orbits of Visual Binary Stars,* U.S. Naval Observatory, online access Oct. 2013.

[7] *Burnham´s Celestial Handbook,* R. Burnham, Jr., Dover Publications, New York 1978.

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