Measurements of 93 Large Delta Magnitude Double Stars with HCDSF instrument, Part 2 from 2023.500 - 2023.999

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Abstract

This report shows the results of 93 double star measurements made with the High Contrast Double Star Filter instrument (HCDSF). During the observations a few new optical components and one possible new double star were found.

1. Introduction

In a previous article a special filter for measurements of high contrast double stars (HCDSF) was introduced and described in detail (Schlimmer, 2023). For the observations an extract of the WDS catalog was compiled first. The WDS catalog was downloaded and imported in an Excel file. To select the target stars some filter criteria were used :

- Coordination : Declination > 0
- Separation : ≥ 6‘‘
- Secondary magnitude : ≤ 12
- Delta magnitude : ≥ 3

With these criteria a list of 2241 doubles stars was compiled for possible observations. Some of these stars were be picked up and marked in the Redshift Planetary software as target. The Redshift Planetary software will be used for mounting control.

After two month of testing and optimization in January and February the HCDSF instrument was transitioned to standard operating mode. This contribution is part 2 of the measurements and covers the time from 2023.500 to 2023.999.

2. Equipment and Methods

For observations a 12-inch Newtonian telescope was used. Focal length is 1500 mm. For the measurement of double stars with large magnitude differences, the HCDSF instrument was mounted on an ocular adapter. In the back focus of the HCDSF instrument a QHY 5-II color CMOS camera was mounted. Image scale is about 0.44 arc seconds per pixel.

Figure 1 : High Contrast Double Star Filter (HCDSF) instrument, ocular sleeve and filter unit in foreground, optical unit and CMOS camera in background. The filter unit consist of a polarization foil F1 and a polarization stripe F2.

The measurements were done in same way as other double stars observations without the HCDSF instrument. For each double star a video with 5 up to 200 frames was recorded. The number of frames depends on the needed exposure time. In general, the longer the exposure time the fewer numbers of frames are recorded. Every frame of the video is like a single measurement. For data analyses REDUC software (Losse, 2016) was used. For each frame, separation and position angle will be automatically analyzed by the ELI interface. The standard deviation for measurements of the separation is usually smaller than ± 0.15 arc seconds. The standard deviation for measurements of the position angle depends on the separation of both components. For double stars with separation of about 5 arc seconds the standard deviation for position angle is usually ±1 degree.

3. Data

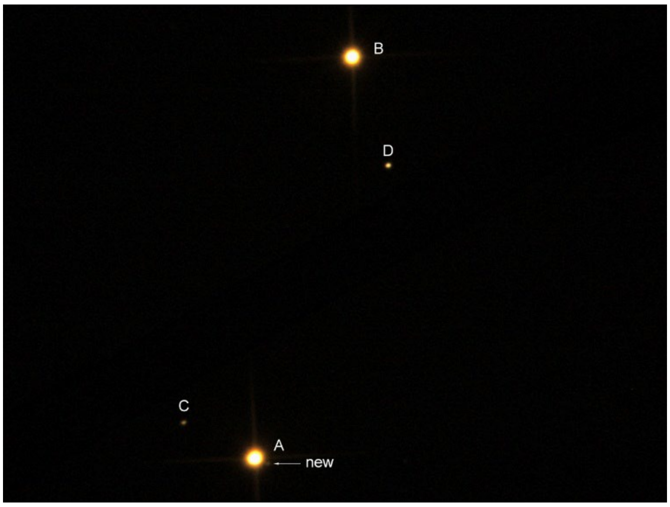
During the measurements new components of v1 CrB and β Lyr were found and will be discussed below. Also, a new double star in the neighborhood of 61 Cygni was found. Its nature is still uncertain.

3.1 New component of v1 CrB, WDS16224+3348, STFA 29, H N 81

In SIMBAD data base v CrB is listed as carbon star with C6 spectrum. In the WDS catalog it is listed as a red giant with a M2IIIab spectrum. The brightness of v CrB is 5.39 mag. At a separation of 355 arc seconds, an optical companion with 8.45 mag is known as STFA 29B (figure 2a). At a separation of 68 arc seconds component C could be found. This pair is already known as H N 81AC. Brightness of component C is 12.62 mag. A fourth component D is also known as STFA 29AD. Its brightness is 11.53 mag.

During my observations I found another component much closer to A at a separation of only 11.78 arc seconds (identified as "STFA 39A(1)" in Table 1). Its brightness is about 14 mag, so the contrast to A is 8.5 mag. Figure 2b shows only the neighborhood of the primary component A, which is covered by the filter F2 of the HCDSF instrument (Schlimmer, 2023). With the HCDSF instrument the brightness of A can be strongly reduced, so the new component outside the filter stripe F2 can be better observed.

Nevertheless, exposure time of each frame was 4 seconds. Finally the contrast of the image was reinforced. That's why a lot of noise caused by hot pixels can be seen.



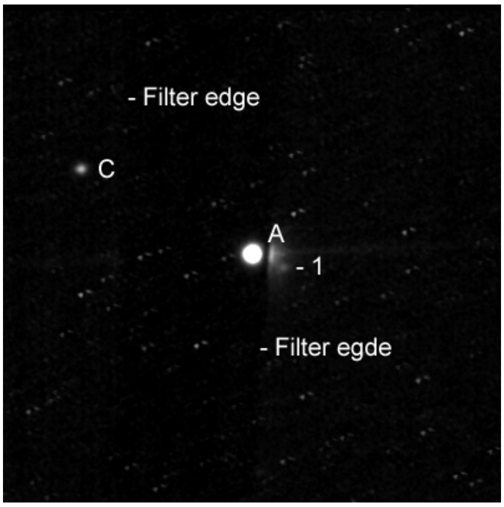


Figure 2a shows an 1280 x 960 pixel image of ν CrB. Exposure time of each frame was 8s. The image is the result of 5 stacked images including dark frame correction. The image was made without HCDSF. Figure 2b shows the new component (1) next to A. Brightness of component A was strongly reduced by the HCDSF.

3.2 New component of β Lyr, WDS18501+3322, STFA 39AB

STFA 39AB is a wide pair with separation of about 45 arc seconds. The brightness of component A is 3.63 mag, brightness of component B is 6.69 mag. Due to similar parallax and proper motion of AB it could be accepted that STFA 39AB is a physical double star. On the other hand, all the other components are optical companions. Figure 3 shows an image of 26 stacked frames. Exposure time of each frame was 2 seconds. Components A, B and E are covered by filter F2 of the HCDSF instrument, so their brightness are reduced by 4 to 5 mag. Component C has a brightness of only 13.0 mag. In distance of 92.29 arc seconds at position angle of 175.4 degree a further optical component was found (identified as "BU 293A(1)" in Table 1). Its brightness is only 14.95 mag (GAIA3 DR3).

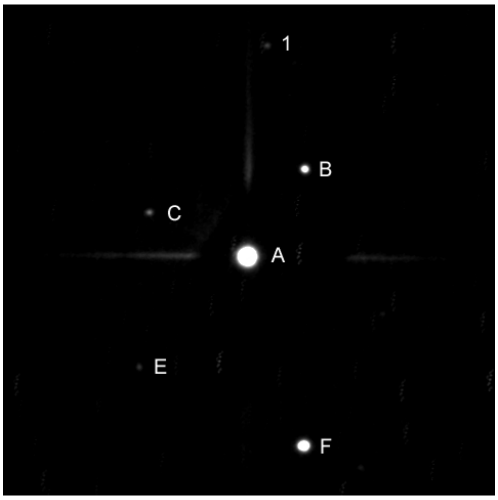


Figure 3 shows STFA 39 with new optical component (1). The image is a result of 26 stacked frames. Exposure time for each frame was 2s.

3.3 New double star next to 61 Cygni

61 Cygni is a well-known double star. Only both bright components AB are of physical nature. Stars in the neighborhood are only optical companions and aren't physically related to the AB components. At a separation of 184 arc seconds at position angle of 241 degree a new faint double star was found. The new double star is labeled as "New double" at the end of table 1. Its brightness can be estimated at 13.5 mag. The difference in brightness between the primary and the secondary component is 0.4 mag. Its separation is 2.24 arc seconds at position angle of 183.9 degree.

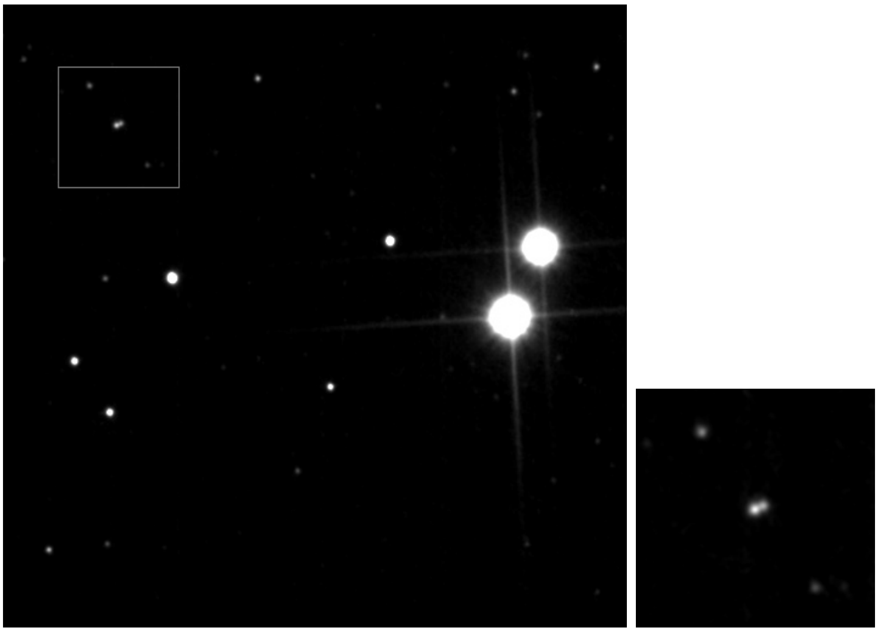


Figure 4a shows 61 Cygni with new double star in the neighborhood. Figure 4b shows a double magnification of the square in 4a. Exposure time was 1s.

3.4 Data

Table 1 shows the results of the 93 measurements with the HCDSF instrument from 2023.500 - 2023.999. The brightness was taken from WDS catalog. Dm is the difference in magnitudes between the primary and secondary component. Average of dm is 6.26 magnitudes. N is the number of observations. Usually, every double star will be observed only one time. Date is given in Julian date (JD).

Table 1 : Results of 93 double star measurements made with the High Contrast Double Star Filter (HCDSF) from 2023.500 - 2023.999

RA+DEC	Code	Magnitudes	dm	PA	SEP	Date	N	Notes
15127+4835	ES 2648AB	7.28,11.25	3.97	340.7	26.35	2023.512	1	
15127+4835	CTT 14AD	7.28,11.21	3.93	60.4	109.68	2023.512	1	
15193+0146	STF1930AB	5.06,10.11	5.05	35.1	11.39	2023.512	1	
15232+3017	STF1937AB,C	4.98,13.35	8.37	357.2	76.7	2023.512	1	
15249+5858	BUP 162	3.42,8.87	5.45	48.8	252.56	2023.512	1	
15303+2739	STF1951	7.89,11.88	3.99	293.7	17.58	2023.512	1	
15348+2500	STT 297	8.3,12.0	3.7	332.6	13.89	2023.512	1	
15402+1203	STT 300	6.32,10.07	3.75	260.9	14.98	2023.512	1	
15440+0231	A 2230AC	5.95,9.23	3.28	207.8	191.92	2023.515	1	

15440+0231	A 2230AD	5.95,10.95	5.00	285.0	172.84	2023.515	1	
15443+0626	HJ 1277AB	2.65,11.8	9.15	332.0	57.86	2023.515	1	
15462+1525	STF1970AB	3.66,9.96	6.3	263.7	30.30	2023.515	1	
16010+3318	S 676	5.47,10.51	5.04	44.5	147.80	2023.515	1	
16052+2211	BU 811AC	8.71,11.92	3.21	307.3	114.60	2023.515	1	
16105+4748	STT 307	7.67,10.71	3.04	201.3	17.48	2023.539	1	
16118+4222	STF2024	5.86,10.73	4.87	44.0	23.22	2023.539	1	
16143-0342	BUP 164AB	2.90,13.4	10.5	307.9	68.35	2023.515	1	
16219+1909	SHJ 227AB	3.76,10.05	6.29	226.5	43.27	2023.539	1	
16224+3348	H N 81AC	5.39,12.62	7.23	241.4	68.36	2023.611	2	
16224+3348	STFA 39A(1)	5.39,13	6.14	65.0	11.78	2023.611	2	v1 CrB
16224+3348	H 6 18BD	5.58,11.53	5.95	16.3	98.30	2023.539	1	
17016+1457	H 4 122	6.28,10.27	3.99	237.8	18.73	2023.682	1	
17146+1423	STF2140AB	3.48,5.40	1.92	103.4	4.72	2023.539	1	without F2
17150+2450	STF3127AB	3.12,8.3	5.18	292.7	13.97	2023.679	1	
17150+2450	STF3127AC	3.12,10.45	7.33	352.8	175.48	2023.679	1	
17150+2450	STF3127AD	3.12,10.59	7.47	89.4	191.62	2023.679	1	
17209+2430	S 687AB	5.12,9.33	4.21	55.5	223.26	2023.679	1	
17237+3709	STF2161AB	4.50,5.40	0.9	320.3	3.94	2023.682	1	
17328+4753	STF2189AB	7.83,11.24	3.41	97.4	20.89	2023.682	1	
17328+4753	STF2189AC	7.83,8.94	1.11	357.5	65.70	2023.682	1	
17346+0935	STFA 34AB	5.80,7.50	1.7	189.7	41.14	2023.679	1	
17395+4600	BU 1459AB	3.76,11.80	8.04	47.6	117.2	2023.682	1	
17479+3417	STT 336AD	6.58,10.64	4.06	162.7	41.17	2023.682	1	
17566+5129	BU 633AB	2.23,13.4	11.17	151.1	20.28	2023.682	1	
17566+5129	BU 633AD	2.23,12.9	10.67	9.8	58.71	2023.682	1	
17566+5129	BU 633AE	2.23,11.9	9.67	233.0	94.68	2023.682	1	
17566+5129	BU 633AF	2.38,11.67	9.29	112.4	124.65	2023.682	1	
17566+5129	BU 633AG	2.38,11.23	8.85	25.5	142.30	2023.682	1	
18011+4521	STF3129	7.59,10.64	3.05	166.7	30.38	2023.682	1	
18058+2127	STT 341AB,C	7.20,10.56	3.36	171.1	28.37	2023.693	1	
18058+2127	STT 341AB,D	7.20,10.48	3.28	100.8	39.44	2023.693	1	
18058+2127	STT 341AB,E	7.20,10.25	3.05	37.5	66.45	2023.693	1	
18058+2127	STT 341AB,G	7.20,7.64	0.44	238.1	132.48	2023.693	1	
18088+2049	AGC 8	4.36,11.8	7.44	136.7	23.07	2023.682	1	
18181+2318	BUP 181AB	6.68,11.5	4.82	222.4	37.45	2023.693	1	
18181+2318	BUP 181AC	6.68,10.04	3.36	124.9	152.98	2023.693	1	
18312+6526	KUI 86	6.64,10.47	3.83	41.9	22.26	2023.693	1	
18369+3846	H 5 39AB	0.09,9.5	9.41	184.8	84.87	2023.742	2	
18369+3846	STFB 9AC	0.09,11.0	10.91	252.1	79.40	2023.725	3	
18369+3846	STFB 9AE	0.09,9.5	9.41	39.0	83.36	2023.742	2	
18369+3846	SMR 33AP	0.09,12.	1.91	84.9	218.40	2023.685	2	
18369+3846	SMR 33AQ	0.09,12.	11.91	120.5	167.20	2023.679	1	
18369+3846	SMR 33AR	0.09,12.	11.91	263.0	181.69	2023.685	2	
18369+3846	SMR 33AT	0.09,12.	11.91	244.6	222.36	2023.685	1	
18426+5532	H 6 37AB	5.01,11.04	6.03	156.0	146.52	2023.693	1	
18443+3940	STFA 37AI	5.15,10.12	4.97	136.6	149.98	2023.693	1	
18443+3940	SHJ 277CD,F	4.56,12.7	8.14	358.5	91.47	2023.682	1	CF not CD, F !
18443+3940	SHJ 277CD,G	4.56,14.2	9.64	289.8	74.68	2023.682	1	CG not CD,G !
18443+3940	SHJ 277CD,H	4.56,13.9	9.34	310.6	94.86	2023.682	1	CH not CD,H !
18443+3940	STF2383CE	5.25,12.3	7.05	332.2	61.84	2023.682	1	
18443+3940	STFA 37CI	5.25,10.12	4.87	36.2	120.28	2023.682	1	
18443+3940	SHJ 277EF	12.3,12.7	0.4	36.0	45.31	2023.682	1	

18499+3233	HO 440	5.25,12.7	7.45	174.6	18.29	2023.693	1	
18501+3322	STFA 39AB	3.63,6.69	3.06	147.6	45.54	2023.685	2	
18501+3322	BU 293AC	3.63,13.0	9.37	246.5	46.64	2023.682	1	
18501+3322	BU 293AE	3.63,10.14	6.51	316.6	67.06	2023.685	2	
18501+3322	BU 293AF	3.63,10.62	6.99	17.5	85.74	2023.685	2	
18501+3322	BU 293A(1)	3.63,14.95	11.32	175.4	92.29	2023.682	2	bet Lyr
18546+3656	ELS 7AB	13.6,13.8	0.2	338.2	8.47	2023.693	1	next to del Lyr
19307+2758	STFA 43AB	3.19,4.68	1.49	53.4	34.49	2023.693	1	bet Cyg
19307+2758	WAL 114AC	3.19,10.99	7.8	339.3	64.79	2023.693	1	
19307+2758	CTT 17AD	3.19,12.24	9.05	31.6	107.05	2023.693	1	
19307+2758	CTT 18AE	3.19,11.81	8.62	205.3	76.08	2023.693	1	
19307+2758	SMR 34AG	3.19,12.5	9.31	43.9	161.2	2023.693	1	
19307+2758	SMR 34AH	3.19,12.5	9.31	118.2	53.88	2023.693	1	
19307+2758	SMR 34AI	3.19,12.5	9.31	131.6	37.38	2023.693	1	
19307+2758	SMR 34AJ	3.19,10.	6.81	209.0	139.09	2023.693	1	
19307+2758	SMR 34AK	3.19,11.5	8.31	276.4	142.0	2023.693	1	
19379+4917	HJ 1428AB	6.60,10.19	3.59	230.1	36.36	2023.805	1	
19379+4917	HJ 1428AC	6.60,10.97	4.37	242.8	64.95	2023.805	1	
19379+4917	HJ 1428BD	10.19,13.8	3.61	272.3	10.90	2023.805	1	
20136+4644	HJ 1495AB	3.93,13.4	9.47	327.4	36.23	2023.805	1	
20136+4644	STFA 50AC	3.93,6.97	3.04	173.0	106.66	2023.805	1	
20136+4644	BU 1483AF	3.93,13.9	9.97	168.0	43.43	2023.805	1	
20136+4644	BU 1483CG	6.97,14.2	7.23	94.7	37.52	2023.805	1	
20136+4644	ES 26DE	4.83,13.2	8.37	248.9	36.7	2023.682	1	
21069+3845	STF2758AB	5.20,6.05	0.85	153.8	32.02	2023.789	1	without HCDSF
21069+3845	STF2758AH	5.35,9.97	4.62	260.3	143.3	2023.805	1	
21069+3845	SMR 1AI	5.35,10.74	5.39	234.7	59.89	2023.805	1	
21069+3845	SMR 40AO	5.35,12.65	7.3	272.7	184.38	2023.805	1	
21069+3845	SMR 40AP	5.35,12.84	7.49	280.3	173.42	2023.805	1	
21069+3845	SMR 40AQ	5.35,13.19	7.84	288.2	81.40	2023.805	1	
21069+3845	New double	13.5,13.9	0.4	113.2	2.24	2023.805	1	d mag =0.4

4. Conclusion

As expected, the measurements have shown that the filter is accurate across a wide range of temperature changes. The temperature range during the observations was from 4°C in Winter to 20°C in Summer. No focus adjustments were needed. The stability was possible thanks to the carbon fiber reinforced plastic tubes.

Due to simultaneous reduction of brightness of close double stars, faint companions could be measured with greater accuracy. For example in epsilon Lyrae the components CF, CG and CH could be measured directly instead of measurements of CD-F, CD-G and CD-H.

Disadvantage of usage the HCDSF instrument is the longer exposure time. Especially in Sommer the S/N of the QHY 5-II color CMOS isn't good by exposure times more than 1s.

Acknowledgements:

This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory.

This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France

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