STT Doubles with Large ΔM – Part III: Vir, Ser, Com, CrB, and Boo

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Abstract: The results of visual double star observing sessions suggested a pattern for STT doubles with large delta_M of being harder to resolve than would be expected based on the WDS catalog data. It was felt this might be a problem with expectations on one hand, and on the other might be an indication of a need for new precise measurements, so we decided to take a closer look at a selected sample of STT doubles and do some research. We found that like in Gem, Leo, and Uma also in Vir, Ser, Com, CrB, and Boo at least several of the selected objects show parameters quite different from the current WDS data.

1. Introduction

As follow up to our reports "STT Doubles with Large delta_M – Part I: Gem and Part II: Leo and UMa" (Knapp, Nanson, and Smith 2015) we continued in the constellations of Vir, Ser, Com, CrB, and Boo which contained 7 objects from our list (see Table1.1) then conveniently located with reasonable altitude. All values were based on WDS data as of the end of 2014 (Table 1.1).

2. Further Research

Following the procedure for parts I and II of our report we concluded again that the best approach would be to check historical data on all objects, observe them visually with the target of comparing with the existing data, and obtain as many images as possible suitable for photometry.

2.1 Changes in Report Structure

Compared with our reports I Gem and II Leo&UMa we changed the structure of our current report at several points:

- We included lines with average results in the table with the photometry results with an additional error estimation based on root mean squares over the

Table 1.1: WDS 2014.96 values for the selected STT objects in Vir, Ser, Com, kCRB, and Boo.

Name	Comp	WDS ID	RA	Dec	Con	Sep	PA	M1	M2	ΔM
STT247	AB	WDS12223+0318	12:22:17.228	+03:17:51.600	Vir	13.8	46	8.70	13.50	4.80
STT282	AB	WDS14260+0714	14:26:00.560	+07:13:52.601	Vir	22.7	216	8.60	11.60	3.00
STT297	AB	WDS15348+2500	15:34:49.411	+24:59:56.697	Ser	12.3	331	8.30	12.30	4.00
STT245	AB	WDS12175+2856	12:17:30.599	+28:56:13.599	Com	8.3	281	5.70	10.20	4.50
STT268	AB	WDS13309+2414	13:30:52.209	+24:14:15.299	Com	18.2	80	7.67	13.00	5.33
STT305	AC	WDS16117+3321	16:11:39.603	+33:20:33.806	CrB	27.8	264	6.44	13.00	6.56
STT289	AB	WDS14560+3218	14:55:58.630	+32:18:00.299	Boo	4.6	110	6.20	10.20	4.00

error values and the standard deviation of the single stacked image results. The average results are calculated over all used telescopes although there are reservations in this regard – but we found that the spread of the results for one telescope is often larger than the spread over different telescopes and concluded that our approach seems to deliver more robust results.

- We extended the table with the astrometry results from using only the average RA/Dec coordinates to single stacked image results plus averages as given so far. This setup shows very nicely the spread of Sep and PA results for the used single stacked images. We changed also the error reporting by including the average plate solving errors dRA and dDec (in arcseconds) for the error estimation for Sep and PA in addition to the standard deviation of the single line results. For Sep error dSep we calculated square root of dRA^2+dDec^2 assuming that the worst case effect of the plate solving error can be considered as conservative error estimation. For PA error dPA we assumed that the worst case would occur if the already calculated dSep would point perpendicular to the separation vector. dPA can then be calculated by the simple trigonometric function arctan(dSep/Sep) in degrees. At first glance it seems a surprise that you can reliably estimate the PA error without direct reference to PA itself but at closer look it is obvious that this relation does not change regardless of PA. The error estimation for the average results was then calculated to include both the root mean squares over the plate solving error and the standard deviation of the single line results.

2.2 Historical Research and Catalog Comparisons

Of the seven stars in this survey, all of them but STT 245 have an interesting history (STT 245 is remarkable for how little it has changed since the first measure). W.J. Hussey's *Micrometrical Observations of the Double Stars Discovered at Pulkovo*, published in 1901, was relied on to provide preliminary historical information on each of the stars. Hussey's book includes his observations and measures of all the stars originally listed in Otto Wilhelm Struve's 1845 Pulkovo Catalog, as well as additional measures from the date of first measure up through 1900. That data, plus inclusion of the background for the Pulkovo Catalog, makes Hussey's book a valuable source of reference. In addition, text files were requested from the WDS for STT 268, STT 289, STT 297, and STT 305.

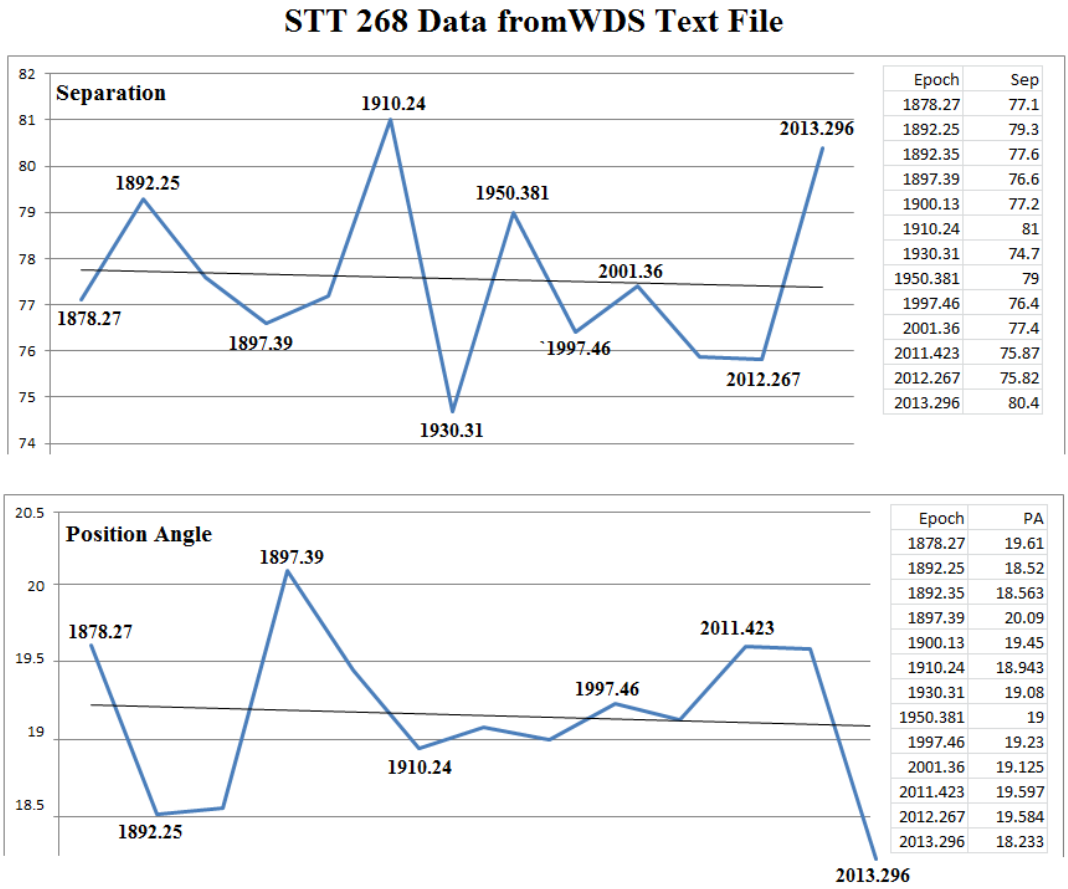
STT 247 (Vir) has the distinction of including a secondary that wasn't included in Otto Struve's original observation. He described the primary as being "perhaps elongated", but provided no measures. Johann Heinrich Mädler made three measures of the elongation: 0.3" in 1846, and 0.25" in both 1847 and 1851. Neither Dembowski nor Burnham saw an elongation in the primary during observations in 1866, 1878, and 1891. Hussey observed STT 247 four times in 1899 and 1900 and also failed to see any hint of a secondary. However he did provide the first measures for the star which is now cataloged as the secondary, arriving at a separation of 12.62" and a position angle of 334.6 degrees, along with estimating the magnitude at 13.5.

STT 268 (Com) was listed in both the main section of the 1845 Pulkovo Catalog and in the appendix (as No. 124). According to Hussey, when the second edition of the Catalog was published, STT 268 was eliminated from the main catalog because its separation exceeded the 16" limit established for companions fainter than ninth magnitude (that criteria applied to the main catalog, whereas the appendix was for pairs which exceeded the criteria). However, neither he nor the WDS text file show that particular measurement by Otto Struve. The first known measure of STT 268 B was made in 1878 by S.W. Burnham (Burnham, 1879, and WDS text file). His results were 19.61" and 77.1°, contrasting with Otto Struve's estimated separation of 12" listed in the 1845 catalog.

The text file for STT 268 was requested in order to see what magnitudes had been assigned to the B component since 1878. The first magnitude shown is 12.1 in 1892, but a further search based on the bibliographic sources in the file showed Burnham had estimated the magnitude at 11.8 in 1878 (Burnham, 1879). A magnitude of 12.7 is shown in the text file for 1930, 12.51 was listed in 2001, followed by the current WDS magnitude (at the time of this paper) of 13.0. STT 268 B was discovered to be double in 2011 (Gatewood, 2012) and designated as GAT 2 (Ba, Bb) with magnitudes of 13.7 and 13.8 being established for the two components. However, those magnitudes weren't listed in Gatewood 2012, nor could their source be identified. Included in Gatewood 2012 is this conflicting note: "the newly discovered star is brighter than B".

In addition to the B component of STT 268, there are two more components, C and D, which are designated as H 5 70 in the WDS (we show those two components as H570 in our astrometry and photometry reports). The C component was discovered by William Herschel in 1783, and the D component was added by S.W. Burnham in 1908.

In looking at the WDS data in the text file for STT 268, it was also discovered the position angle and separation reported as the most recent in the WDS (2013.296) was significantly different than prior



Epoch	Sep
1878.27	77.1
1892.25	79.3
1892.35	77.6
1897.39	76.6
1900.13	77.2
1910.24	81
1930.31	74.7
1950.381	79
1997.46	76.4
2001.36	77.4
2011.423	75.87
2012.267	75.82
2013.296	80.4

Epoch	PA
1878.27	19.61
1892.25	18.52
1892.35	18.563
1897.39	20.09
1900.13	19.45
1910.24	18.943
1930.31	19.08
1950.381	19
1997.46	19.23
2001.36	19.125
2011.423	19.597
2012.267	19.584
2013.296	18.233

Figure 2.2.1: STT 269 Position Angles and Separations, 1878 through 2013; WDS text file data shown at right.

measures. Figure 2.2.1 shows how that data compares with prior data, as well as the trend line for the historical data.

STT 282 (Vir) is another pair that was eliminated in the second edition of the Pulkovo Catalog because its separation exceeded the 16" limit referred to above in the STT 268 discussion. Hussey measured it at 22.81" and 216.0° in 1898, which is virtually identical with the last measure shown in the WDS (2013) of 22.90" and 216.0°. Also, Hussey showed the secondary at a magnitude of 11.5, while Burnham listed it at 11.3 in his 1906 catalog.

STT 289 (Boo) shows a slow, but steady, change in both position angle and separation, as the trend line in the graphs in Figure 2.2.2 show. However, there are also some notable spikes in the position angle, as well as one in separation. The most recent data from the URAT1 catalog shows the primary's proper motion at -058 -008, but no PM data is available on the secondary.

STT 297 (Ser) is notable for a curious change in position angle, which at first glance leaves the impression it was measured incorrectly from 1845 through 1923. The WDS text file shows an approximate 180 degree change in positon angle taking place between 1916 and 1933. A close look at the data also shows major changes in separation as well. The clue as to what took place is a 1958 comment by Paul Cousteau, which is provided in the notes section of the text file: "Optical pair; apparent movement of companion 15"/century along position angle 333 deg. Minimum separation of 0.8" in 1933." The URAT1 catalog shows the proper motion of the primary at +069 -113 and the secondary at -011 +014. So in effect the motion of the primary relative to the secondary resulted in a gradual reversal of position angle before and after the closest approach in 1933. You can see that motion take place by overlaying data from NOMAD, UCAC4, or URAT1 on the image of STT 297 in Aladin and using the epoch

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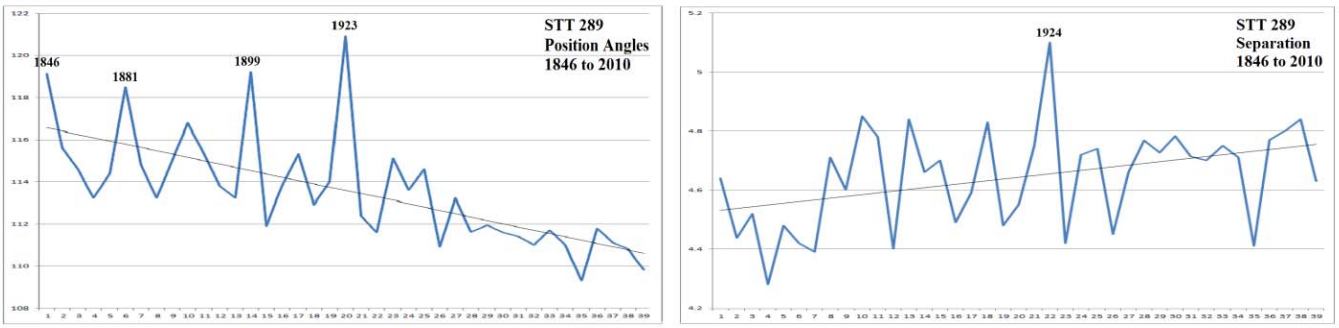

Figure 2.2.2: Measured Position Angles and Separations of STT 289, 1846 through 2010.

slider at the right hand side of the window to move from 2000 through 1933 and beyond.

STT 305 is unique among the group of stars in this series for an entirely different and unexpected reason: two of the four components listed in the WDS have never been seen after the first observations were measured and recorded. The WDS text file shows the C component was measured by Mädler in 1847 at a distance of 27.80" and a position angle of 264 degrees, with an estimated magnitude of 13.0. The file also shows attempts were made to locate the C component in 1947, 2009, and 2012, none of which succeeded. S.W. Burnham went in search of the C component in 1905 with the aid of the 40 inch refractor at Yerkes Observatory, which resulted in this observational note: "Mä(dler) measures a distant star, 264.0° : 27.82" (1847.35) which Hu(ssey) could not see with the 12-inch. The 40-inch shows nothing in that place, but there is a small star, 85.8° : 62.68" (1905.54). [Burnham, 1906, p. 707]. The star referred to at 85.8° is listed in the WDS as the D component, also with a magnitude of 13.0, but no observation or measure since Burnham's 1905 data is shown in the text file. Undoubtedly attempts have been made since 1905 to locate that star, but none are listed in the WDS file. Our examinations of images of STT 305, as well as our own observations, show there are no matching 13th magnitude stars to be found in the vicinity of either the C or the D component.

2.3 Visual Observations

Both John Nanson and Wilfried Knapp made visual observations of the stars listed in Table 1.1. of this report. Nanson used a 152mm f/10 refractor and a 235mm SCT, while Knapp utilized 140mm and 185mm refractors and a 235mm SCT, as well as a masking device to evaluate what could be seen at lesser apertures.

Table 2.2.1: Measures of STT297

Year	PA	Sep	Year	PA	Sep
1847	148.0	13.00	1911	134.3	3.24
1847	147.5	12.98	1916	131.6	2.57
1867	147.8	10.23	1923	116.2	1.22
1882	142.4	7.88	1933	323.3	0.95
1889	142.1	6.84	1957	342.0	3.56
1893	140.9	5.86	1958	340.5	3.92
1893	142.8	6.12	1958	341.1	3.70
1897	140.7	5.48	1959	339.8	4.08
1897	144.9	5.62	1962	339.2	4.72
1897	138.4	5.47	1975	337.4	6.65
1898	140.2	5.26	1987	334.4	6.83
1901	137.3	4.61	1999	333.4	10.30
1903	136.1	4.31	2002	333.1	10.47
1903	139.1	4.26	2002	333.0	10.54
1904	135.9	3.90	2003	333.3	10.74
1909	135.5	3.47	2013	332.4	12.45
1910	130.4	3.23	2014	331.2	12.30

WDS Text File Data

STT 245 (Com): Knapp observed this pair twice and caught sight of the secondary both times, once in a 235mm SCT and once in a 185mm refractor. His impression during the first observation was the secondary may be much fainter than listed, although the glare from the primary may have also caused that impression. Nanson observed STT 245 once with a 235mm SCT and caught a few glimpses of the secondary at 94x, and rated the difficulty as being what would be expected given the magnitude differential of 4.5 and

separation of 8". Interestingly, both observers found lower magnifications were better for revealing the secondary than high magnifications.

STT 247 (Vir): Neither Nanson, who looked at this star once, nor Knapp, who looked at it three times, were able to see the secondary of this pair. This was a difficult observation, given the magnitude differential of 4.80 and separation of 13.80", but our experience on STT 245 above would indicate the secondary should have been within visual reach in the 185mm and 235mm apertures which were used, leaving the impression it may be fainter than the WDS value of 13.50.

STT 268 (Com): Knapp observed STT 268 B three times (apertures of 140mm, 185mm, and 235mm) and concluded each time that B was slightly brighter than the 13.00 magnitude listed in the WDS. Nanson observed the secondary twice with an aperture of 235mm and concluded B was similar in magnitude to D, which is listed in the WDS at 13.46 (that value seems to be confirmed by NOMAD1 and UCAC4 data).

STT 282 (Vir): Nanson observed this pair twice with an aperture of 235mm and came away both times with the impression the secondary was about half a magnitude fainter than the WDS value of 11.60. Knapp observed it three times (apertures of 140, 185, and 235mm) and found the secondary closely matched to slightly brighter than the WDS magnitude.

STT 289 (Boo): Knapp observed this pair four times (apertures of 140, 185, and 235mm), but for the most part had little luck due to poor seeing. He was able to catch sight of the secondary on the last attempt with the 185mm refractor and felt it was similar to STT 245 B (WDS magnitude of 10.2), but the observation was cut short by clouds. Nanson made one attempt at this pair with a 235mm SCT and failed to see the secondary with magnifications ranging from 61x to 175x.

STT 297 (Ser): Nanson observed this pair once with a 235mm SCT and found the secondary to be slightly fainter than the WDS value of 12.30 by about .3 of a magnitude, based on a nearby comparison star with a UCAC4 Vmag of 12.585. Knapp observed it three times using apertures of 140mm, 185mm, and 235mm. During the first observation (235mm) he came to the same conclusion Nanson did, based on the same comparison star. During the second observation he was able to see the secondary while using an 80mm mask on the 140mm refractor, which led to the conclusion the secondary must be quite a bit brighter than the WDS value of 12.3.

STT 305 (CrB): Knapp observed STT 305B twice with an aperture of 235mm, was unable to see it the first time due to poor seeing, and resolved it at 120x during the second observation. Nanson observed it once with a 235mm SCT, was able to see B weakly at 94x, and confirmed it at 136x and 245x. He felt it was slightly brighter than the 10.17 magnitude listed for it in the WDS.

2.4 Photometry and Astrometry

2.4.1 Photometry Results

Several hundred images were taken with iTelescope remote telescopes and photometry was performed with AAVSO VPhot and Astrometrica with the same sequence for the different stacked images mostly of 5 images with 1s exposure time. The resulting photometry reports are shown in Table 2.4.1.1.

Specifications of the used telescopes:

iT11: 510mm CDK with 2280mm focal length. CCD: FLI ProLine PL11002M. Resolution 0.81 arcsec/pixel. B- and V-Filter. Transformation coefficients B-V available. Located in Mayhill, New Mexico. Elevation 2225m

iT17: 431mm CDK with 2912mm focal length. CCD: FLI ProLine PL4710. Resolution 0.92 arcsec/pixel. B and V-filter. Transformation coefficients available. Located in Siding Spring, Australia. Elevation 1122m

iT18: 318mm CDK with 2541mm focal length. CCD: SBIG-STXL-6303E. Resolution 0.73 arcsec/pixel. V-filter. No transformation coefficients available. Located in Nerpio, Spain. Elevation 1650m

iT21: 431mm CDK with 1940mm focal length. CCD: FLI-PL6303E. Resolution 0.96 arcsec/pixel. V-filter. Transformation coefficients V-R available, but not used. Located in Mayhill, New Mexico. Elevation 2225m

iT24: 610mm CDK with 3962mm focal length. CCD: FLI-PL09000. Resolution 0.62 arcsec/pixel. V-filter. No transformation coefficients available. Located in Auberry, California. Elevation 1405m

2.4.2 Astrometry Results

Astrometry calculations were done for all objects regardless if position issues were assumed or not. We used Astrometrica as tool to determine the RA/Dec coordinates for all components based on plate solving with the UCAC4 catalog as reference. The RA/Dec coordinates based on this approach were used to calculate the Sep and PA listed in Table 2.4.2.1 using the formula provided by R. Buchheim (2008). Similar to photometry, we report the results per stacked image separately but give also average results for RA/Dec coordinates, separation, and position angle as well.

(Continued on page 140)

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*Table 2.4.1.1: Photometry results for the selected STT objects in Vir, Ser, Com, CrB, and Boo. Mag2 means magnitude for secondary. SNR stands for Signal to Noise Ratio. Err(SNR) is calculated as 2.5*Log10(1+1/SNR). Std is the standard deviation calculated in relation to the used comparison stars. Err is calculated as square root of (Std^2 + Err(SNR)^2). N is the number of images (usually with 1s exposure time) used for the reported values. Date is the Bessel epoch of the observation. Scope indicates the telescope used and Notes refer to a note number. The summary line per object gives the average Vmag and observation date as well as the RMS (root mean square over the Err values) and the total error estimation "+STD" calculated as SQRT(RMS^2+STD^2) with STD standing for the standard deviation of the Vmag measurement results of the single stacked images. The N column gives the total number of images used in the summary line.*

Name	Comp	Con	Mag2	Err	Std	Err(SNR)	SNR	Date	N	Scope	Notes
STT247	B	Vir	13.572	0.126	0.028	0.123	8	2015.452	2	iT18	
			13.436	0.158	0.019	0.157	6	2015.448	4	iT21	
			13.553	0.102	0.020	0.100	10	2015.451	2	iT24	
			13.406	0.108	0.029	0.104	10	2015.483	3	iT24	
			13.443	0.095	0.003	0.094	11	2015.456	4	iT24	
			13.510	0.093	0.003	0.093	11	2015.464	4	iT24	
			13.311	0.069	0.004	0.069	15	2015.459	5	iT24	
Mean/RMS/+STD			13.462	0.110	0.139			2015.459	24		
STT282	B	Vir	11.786	0.036	0.034	0.011	97	2015.632	3	iT17	1
			11.728	0.018	0.017	0.006	182	2015.632	5	iT17	
			11.725	0.012	0.011	0.004	246	2015.632	5	iT17	
			11.751	0.051	0.042	0.029	37	2015.452	2	iT18	
			11.861	0.040	0.001	0.040	27	2015.448	5	iT21	
			11.765	0.034	0.026	0.023	48	2015.451	2	iT24	
			11.719	0.045	0.039	0.022	49	2015.464	3	iT24	
			11.753	0.036	0.030	0.020	54	2015.456	5	iT24	
			11.797	0.067	0.064	0.020	54	2015.459	5	iT24	
Mean/RMS/+STD			11.765	0.041	0.061			2015.514	35		
STT297	B	Ser	12.015	0.045	0.037	0.026	41	2015.452	5	iT18	
			11.922	0.076	0.058	0.049	22	2015.448	5	iT21	
			11.943	0.063	0.057	0.027	40	2015.399	3	iT24	
			12.031	0.040	0.033	0.022	48	2015.456	5	iT24	
			12.003	0.033	0.025	0.021	51	2015.459	5	iT24	
			11.900	0.073	0.069	0.025	44	2015.462	6	iT24	
Mean/RMS/+STD			11.969	0.057	0.076			2015.446	29		
STT245	B	Com	10.823	0.077	0.068	0.037	29	2015.470	4	iT11	
			10.667	0.047	0.045	0.014	76	2015.452	2	iT18	
			10.735	0.074	0.072	0.017	62	2015.448	5	iT21	
			10.788	0.064	0.063	0.013	85	2015.425	2	iT24	
			10.696	0.041	0.040	0.010	107	2015.462	4	iT24	
			10.652	0.034	0.033	0.010	111	2015.456	5	iT24	
Mean/RMS/+STD			10.727	0.059	0.085			2015.452	22		
STT268	B	Com	12.990	0.068	0.039	0.056	19	2015.452	4	iT18	2
			13.013	0.136	0.111	0.078	13	2015.459	1	iT24	
			12.963	0.115	0.104	0.049	22	2015.456	5	iT24	
Mean/RMS/+STD			12.989	0.110	0.112			2015.456	10		
GAT2	Ba	Com	13.097	0.147	0.087	0.118	9	2015.399	1	iT24	3
			12.953	0.059	0.036	0.047	23	2015.464	5	iT24	
Mean/RMS/+STD			13.025	0.112	0.133			2015.432	6		
GAT2	Bb	Com	13.107	0.145	0.087	0.116	9	2015.399	1	iT24	3
			13.125	0.068	0.036	0.058	18	2015.464	5	iT24	
Mean/RMS/+STD			13.116	0.113	0.114			2015.432	6		

Table 2.4.1.1 concludes on next page.

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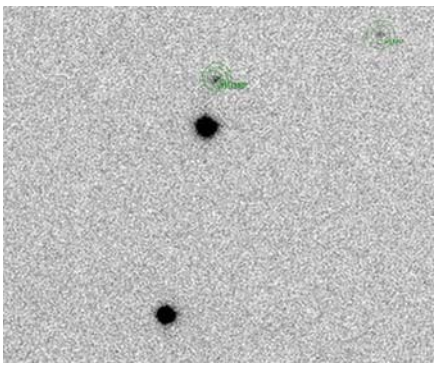
Table 2.4.1.1 (conclusion): Photometry results for the selected objects ...

Name	Comp	Con	Mag2	Err	Std	Err(SNR)	SNR	Date	N	Scope	Notes
H570	D	Com	13.597	0.093	0.039	0.085	12	2015.452	4	iT18	
			13.544	0.182	0.087	0.160	6	2015.399	1	iT24	
			13.765	0.198	0.111	0.164	6	2015.459	1	iT24	
			13.366	0.121	0.104	0.061	17	2015.456	5	iT24	
			13.422	0.072	0.036	0.062	17	2015.464	5	iT24	
Mean/RMS/+STD			13.539	0.142	0.199			2015.446	16		
STT305	B	CrB	10.142	0.051	0.049	0.012	87	2015.470	5	iT11	4
			10.268	0.034	0.026	0.022	48	2015.435	3	iT18	
			10.205	0.081	0.800	0.120	87	2015.448	5	iT21	
			10.367	0.010	0.004	0.009	123	2015.399	4	iT24	
			10.094	0.044	0.043	0.007	144	2015.456	5	iT24	
			10.103	0.026	0.025	0.007	159	2015.459	5	iT24	
			10.196	0.034	0.033	0.007	149	2015.462	5	iT24	
Mean/RMS/+STD			10.196	0.045	0.100			2015.447	32		
STT289	B	Boo	11.030	0.034	0.016	0.030	36	2015.452	5	iT18	5
			11.106	0.046	0.035	0.030	35	2015.459	1	iT24	
			11.190	0.054	0.044	0.031	35	2015.464	2	iT24	
Mean/RMS/+STD			11.109	0.045	0.080			2015.458	8		

Notes:

1. As the visual impressions of STT282B were highly different we assumed a color issue here and decided to take images with B- and V-filter to be able to calculate a color index. As Vir was already too low in altitude in the northern hemisphere we did this with a telescope located in Australia. This resulted in a B-V color index of 1.104 indicating a reddish hue of B with the effect of appearing rather faint to the visual observer and the given numbers for iT17 are then transformed with this value to Landolt (1992) standard even if giving only minor corrections. And these results are very similar to the iT24 values showing that the iT24 color personality is rather neutral, although it might be of interest to calculate transformation coefficients also for this telescope according to the procedure described by Benson (1998) but currently there is no B filter available.
2. STT268B is actually a double itself - GAT2BaBb 1.6" +13.7/13.8 mag. We managed to catch this faint and rather close double at least in one image. There is also a D component listed as H570 79.9" +7.67/13.46 mag.



3. The calculated combined magnitude of Ba and Bb would give ~12.35mag for STT268B, means far brighter than the direct photometry results above. This seems to be a regular pattern that photometry for combined objects does not match the calculated combined magnitude.
4. STT305 was selected for the C component given with +13.00 mag. During visual observations and historical research we realized both STT 305 C and D were bogus. To make use of the existing imaging material we then did photometry for B with 5" separation and +10.17 mag to check the validity of the visual magnitude given for this component. We decided to go here with Tycho objects for reference stars as we have the impression that UCAC4 Vmags are less reliable for stars brighter than +11 mag. In average we got over all images for STT305B +10.196 mag – confirming the current WDS value rather nicely.
5. STT289 proved to be a difficult object for photometry, with few stars in the field of view already making problems with plate solving but also not very suitable for comparison stars. The heavily overlapping star disks of A and B posed another challenge for photometry. VPhot was in this case not suitable for doing this task so we had to resort to Astrometrica. Due to the plate solving problems only a few images were usable so the listed results might be somewhat irregular.

STT Doubles with Large ΔM – Part III: Vir, Ser, Com, CrB and Boo

Table 2.4.2.1: Astrometry results for the selected STT objects in Vir, Ser, Com, CrB and Boo. dRA and dDec gives the plate solving error for the referred stacked image. Sep means separation in arcseconds and dSep gives the plate solve error calculated as SQRT(dRA^2+dSep^2). PA means position angle in degrees and dPA is calculated as arctan(dSep/Sep). The average results are given in the line below the individual stacks. The plate solving error is calculated as root mean square over the dRA and dDec values for the individual stacked images. The Sep and PA error estimation for the average line is calculated to include both the root mean squares over the plate solving based error and the standard deviation of the individual stack results

Object		RA	Dec	dRA	dDec	Sep	dSep	PA	dPA	Date	Notes
STT247 WDS12223+0318	A	12:22:17.000	03:17:52.060	0.18	0.18	14.073	0.255	47.154	1.036	2015.452	1
	B	12:22:17.694	03:18:01.469								
STT247 WDS12223+0318	A	12:22:17.011	03:17:51.790	0.11	0.14	14.070	0.178	46.809	0.725	2015.448	2
	B	12:22:17.696	03:18:01.420								
STT247 WDS12223+0318	A	12:22:17.014	03:17:51.900	0.14	0.13	14.015	0.191	47.047	0.781	2015.451	3
	B	12:22:17.699	03:18:01.450								
STT247 WDS12223+0318	A	12:22:17.009	03:17:51.850	0.14	0.14	14.203	0.198	45.979	0.799	2015.483	4
	B	12:22:17.691	03:18:01.720								
STT247 WDS12223+0318	A	12:22:17.000	03:17:51.820	0.14	0.19	14.252	0.236	46.998	0.949	2015.456	5
	B	12:22:17.696	03:18:01.540								
STT247 WDS12223+0318	A	12:22:17.008	03:17:51.830	0.14	0.21	13.895	0.252	47.765	1.041	2015.464	6
	B	12:22:17.695	03:18:01.170								
STT247 WDS12223+0318	A	12:22:17.019	03:17:51.980	0.16	0.19	13.761	0.248	47.086	1.034	2015.459	7
	B	12:22:17.692	03:18:01.350								
STT247 WDS12223+0318	**A**	**12:22:17.009**	**03:17:51.890**	**0.146**	**0.171**	**14.038**	**0.274**	**46.947**	**1.041**	**2015.459**	**8**
	B	**12:22:17.694**	**03:18:01.469**								
STT282 WDS14260+0714	A	14:26:00.457	07:13:51.400	0.16	0.15	22.862	0.219	216.321	0.550	2015.632	9
	B	14:25:59.547	07:13:32.980								
STT282 WDS14260+0714	A	14:26:00.456	07:13:51.660	0.15	0.21	22.859	0.258	216.142	0.647	2015.632	10
	B	14:25:59.550	07:13:33.200								
STT282 WDS14260+0714	A	14:26:00.438	07:13:51.220	0.16	0.200	22.355	0.256	216.329	0.656	2015.632	11
	B	14:25:59.548	07:13:33.210								
STT282 WDS14260+0714	A	14:26:00.444	07:13:51.550	0.20	0.12	22.898	0.233	215.978	0.584	2015.452	12
	B	14:25:59.540	07:13:33.020								
STT282 WDS14260+0714	A	14:26:00.447	07:13:51.340	0.17	0.155	22.869	0.227	216.262	0.568	2015.448	13
	B	14:25:59.538	07:13:32.900								
STT282 WDS14260+0714	A	14:26:00.445	07:13:51.500	0.12	0.13	22.934	0.177	216.143	0.442	2015.451	14
	B	14:25:59.536	07:13:32.980								
STT282 WDS14260+0714	A	14:26:00.429	07:13:51.710	0.12	0.14	22.897	0.184	216.157	0.461	2015.464	15
	B	14:25:59.543	07:13:32.990								
STT282 WDS14260+0714	A	14:26:00.440	07:13:51.660	0.19	0.11	22.923	0.220	215.979	0.549	2015.456	16
	B	14:25:59.535	07:13:33.110								
STT282 WDS14260+0714	A	14:26:00.449	07:13:51.200	0.18	0.14	22.586	0.228	217.075	0.578	2015.459	17
	B	14:25:59.534	07:13:33.180								
STT282 WDS14260+0714	**A**	**14:26:00.445**	**07:13:51.471**	**0.163**	**0.153**	**22.797**	**0.290**	**216.152**	**0.732**	**2015.514**	**18**
	B	**14:25:59.541**	**07:13:33.063**								
STT297 WDS15348+2500	A	15:34:49.505	24:59:55.040	0.16	0.15	12.667	0.219	332.446	0.992	2015.452	19
	B	15:34:49.074	25:00:06.270								
STT297 WDS15348+2500	A	15:34:49.499	24:59:55.190	0.12	0.19	12.606	0.225	332.581	1.021	2015.448	20
	B	15:34:49.072	25:00:06.380								

Table 2.4.3.1 continues on next page.

STT Doubles with Large ΔM – Part III: Vir, Ser, Com, CrB and Boo

Table 2.4.2.1 (continued): Astrometry results for the selected STT objects ...

Object		RA	Dec	dRA	dDec	Sep	dSep	PA	dPA	Date	Notes
STT297 WDS15348+2500	A	15:34:49.494	24:59:55.090	0.15	0.14	12.677	0.205	332.262	0.927	2015.399	21
	B	15:34:49.060	25:00:06.310								
STT297 WDS15348+2500	A	15:34:49.507	24:59:55.130	0.13	0.13	12.882	0.184	332.536	0.818	2015.456	22
	B	15:34:49.070	25:00:06.560								
STT297 WDS15348+2500	A	15:34:49.504	24:59:55.080	0.14	0.14	12.721	0.198	332.367	0892	2015.459	23
	B	15:34:49.070	25:00:06.350								
STT297 WDS15348+2500	A	15:34:49.504	24:59:55.070	0.18	0.16	12.736	0.241	332.333	1.083	2015.462	24
	B	15:34:49.069	25:00:06.350								
STT297 WDS15348+2500	**A**	**15:34:49.502**	**24:59:55.100**	**0.148**	**0.153**	**12.715**	**0.229**	**332.421**	**0.965**	**2015.446**	**25**
	B	**15:34:49.069**	**25:00:06.370**								
STT245 WDS12175+2856	A	12:17:30.514	28:56:14.07	0.26	0.27	8.375	0.375	281.572	2.563	2015.470	26
	B	12:17:29.889	28:56:15.75								
STT245 WDS12175+2856	A	12:17:30.535	28:56:14.51	0.11	0.13	8.402	0.170	280.022	1.161	2015.452	27
	B	12:17:29.909	28:56:16.26								
STT245 WDS12175+2856	A	12:17:30.539	28:56:14.24	0.13	0.15	8.329	0.198	281.847	1.365	2015.448	28
	B	12:17:29.918	28:56:15.95								
STT245 WDS12175+2856	A	12:17:30.542	28:56:14.36	0.18	0.22	8.347	0.284	281.541	1.950	2015.425	29
	B	12:17:29.918	28:56:16.03								
STT245 WDS12175+2856	A	12:17:30.524	28:56:14.47	0.16	0.12	8.402	0.200	282.022	1.364	2015.462	30
	B	12:17:29.898	28:56:16.22								
STT245 WDS12175+2856	A	12:17:30.531	28:56:14.31	0.16	0.16	8.373	0.226	281.505	1.548	2015.456	31
	B	12:17:29.906	28:56:15.98								
STT245 WDS12175+2856	**A**	**12:17:30.53**	**28:56:14.38**	**0.173**	**0.183**	**8.371**	**0.253**	**281.752**	**1.738**	**2015.452**	**32**
	B	**12:17:29.90**	**28:56:16.03**								
STT268 WDS13309+2414	A	13:30:52.214	24:14:15.77	0.16	0.12	18.932	0.200	77.431	0.605	2015.452	33
	B	13:30:53.565	24:14:19.89								
STT268 WDS13309+2414	A	13:30:52.200	24:14:16.03	0.16	0.16	19.166	0.226	77.799	0.678	2015.459	34
	B	13:30:53.566	24:14:20.07								
STT268 WDS13309+2414	A	13:30:52.209	24:14:15.79	0.12	0.16	19.150	0.200	77.331	0.598	2015.456	35
	B	13:30:53.575	24:14:19.99								
STT268 WDS13309+2414	**A**	**13:30:52.208**	**24:14:15.863**	**0.148**	**0.148**	**19.066**	**0.230**	**77.520**	**0.660**	**2015.456**	**36**
	B	**13:30:53.569**	**24:14:19.983**								
H570 WDS13309+2414	A	13:30:52.214	24:14:15.77	0.16	0.12	78.811	0.200	26.534	0.145	2015.452	37
	D	13:30:54.788	24:15:26.28								
H570 WDS13309+2414	A	13:30:52.216	24:14:15.76	0.12	0.11	78.533	0.163	26.601	0.119	2015.399	38
	D	13:30:54.787	24:15:25.98								

Table 2.4.3.1 continues on next page.

STT Doubles with Large ΔM – Part III: Vir, Ser, Com, CrB and Boo

Table 2.4.2.1 (continued): Astrometry results for the selected STT objects ...

Object		RA	Dec	dRA	dDec	Sep	dSep	PA	dPA	Date	Notes
H570 WDS13309+2414	A	13:30:52.200	24:14:16.03	0.16	0.16	78.411	0.226	26.814	0.165	2015.459	39
	D	13:30:54.786	24:15:26.01								
H570 WDS13309+2414	A	13:30:52.209	24:14:15.79	0.12	0.16	78.766	0.200	26.517	0.145	2015.456	40
	D	13:30:54.780	24:15:26.27								
H570 WDS13309+2414	A	13:30:52.210	24:14:15.81	0.15	0.12	78.797	0.192	26.594	0.140	2015.464	41
	D	13:30:54.789	24:15:26.27								
H570 WDS13309+2414	**A**	**13:30:52.210**	**24:14:15.832**	**0.143**	**0.136**	**78.663**	**0.255**	**26.612**	**0.179**	**2015.446**	**42**
	D	**13:30:54.786**	**24:15:26.162**								
GAT2 WDS13309+2414	Ba	13:30:53.570	24:14:19.67	0.12	0.11	1.412	0.163	48.250	6.578	2015.399	43
	Bb	13:30:53.647	24:14:20.61								
GAT2 WDS13309+2414	Ba	13:30:53.543	24:14:19.14	0.15	0.12	1.219	0.192	34.898	8.953	2015.464	44
	Bb	13:30:53.594	24:14:20.14								
GAT2 WDS13309+2414	**Ba**	**13:30:53.556**	**24:14:19.405**	**0.136**	**0.115**	**1.307**	**0.202**	**42.064**	**10.236**	**2015.432**	**45**
	Bb	**13:30:53.621**	**24:14:20.375**								
STT305 WDS16117+3321	A	16:11:39.619	33:20:34.360	0.21	0.24	5.136	0.319	263.180	3.553	2015.470	46
	B	16:11:39.212	33:20:33.750								
STT305 WDS16117+3321	A	16:11:39.603	33:20:34.030	0.10	0.10	5.529	0.141	263.040	1.465	2015.435	47
	B	16:11:39.165	33:20:33.360								
STT305 WDS16117+3321	A	16:11:39.595	33:20:34.250	0.09	0.14	5.328	0.166	262.992	1.789	2015.448	48
	B	16:11:39.173	33:20:33.600								
STT305 WDS16117+3321	A	16:11:39.608	33:20:34.340	0.15	0.15	6.272	0.212	267.441	1.937	2015.399	49
	B	16:11:39.108	33:20:34.060								
STT305 WDS16117+3321	A	16:11:39.596	33:20:34.040	0.16	0.16	5.174	0.226	264.455	2.504	2015.456	50
	B	16:11:39.185	33:20:33.540								
STT305 WDS16117+3321	A	16:11:39.607	33:20:34.160	0.12	0.14	5.628	0.184	263.265	1.877	2015.459	51
	B	16:11:39.161	33:20:33.500								
STT305 WDS16117+3321	A	16:11:39.605	33:20:34.140	0.14	0.11	5.658	0.178	267.164	1.802	2015.462	52
	B	16:11:39.154	33:20:33.860								
STT305 WDS16117+3321	**A**	**16:11:39.605**	**33:20:34.189**	**0.144**	**0.154**	**5.529**	**0.416**	**264.589**	**2.849**	**2015.447**	**53**
	B	**16:11:39.165**	**33:20:33.667**								
STT289 WDS14560+3218	A	14:55:58.530	32:18:00.240	0.18	0.14	4.524	0.228	112.347	2.886	2015.452	54
	B	14:55:58.860	32:17:58.520								
STT289 WDS14560+3218	A	14:55:58.531	32:18:00.150	0.13	0.14	5.420	0.191	104.968	2.019	2015.612	55
	B	14:55:58.944	32:17:58.750								
STT289 WDS14560+3218	A	14:55:58.528	32:18:00.110	0.20	0.15	6.038	0.250	108.342	2.371	2015.612	56
	B	14:55:58.980	32:17:58.210								

Table 2.4.3.1 concludes on next page.

STT Doubles with Large ΔM – Part III: Vir, Ser, Com, CrB and Boo

Table 2.4.2.1 (conclusion): Astrometry results for the selected STT objects ...

Object		RA	Dec	dRA	dDec	Sep	dSep	PA	dPA	Date	Notes
STT289 WDS14560+3218	A	14:55:58.540	32:18:00.030	0.08	0.13	5.649	0.153	103.618	1.548	2015.612	57
	B	14:55:58.973	32:17:58.700								
STT289 WDS14560+3218	A	14:55:58.527	32:17:59.900	0.04	0.01	5.651	0.041	109.541	0.418	2015.459	58
	B	14:55:58.947	32:17:58.010								
STT289 WDS14560+3218	A	14:55:58.520	32:17:59.980	0.02	0.25	4.620	0.251	108.290	3.107	2015.615	59
	B	14:55:58.866	32:17:58.530								
STT289 WDS14560+3218	A	14:55:58.525	32:18:00.040	0.1	0.15	4.131	0.186	106.742	2.578	2015.464	60
	B	14:55:58.837	32:17:58.850								
STT289 WDS14560+3218	A	14:55:58.518	32:18:00.100	0.14	0.19	4.827	0.236	104.271	2.799	2015.615	61
	B	14:55:58.887	32:17:58.910								
STT289 WDS14560+3218	A	14:55:58.527	32:18:00.090	0.14	0.19	4.329	0.236	110.414	3.120	2015.615	62
	B	14:55:58.847	32:17:58.580								
STT289 WDS14560+3218	**A**	**14:55:58.527**	**32:18:00.071**	**0.129**	**0.162**	**5.021**	**0.674**	**107.615**	**3.652**	**2015.562**	**63**
	B	**14:55:58.905**	**32:17:58.562**								

Notes for Table 2.4.2.1

1. STT247 iT18 stack 2x3s
2. STT247 iT21 stack 4x1s
3. STT247 iT24 stack 2x1s
4. STT247 iT24 stack 3x1s
5. STT247 iT24 stack 4x1s
6. STT247 iT24 stack 4x1s_2
7. STT247 iT24 stack 5x1s
8. Mean values for Sep and PA over the 7 stacked images (with a total number of 24 images) indicated above. Rms_dSep 0.225 and Sep standard deviation 0.157, rms_dPA 0.917 and PA standard deviation 0.492
9. STT282 iT17 stack 3x6s transformed
10. STT282 iT17 stack 5x9s transformed
11. STT282 iT17 stack 5x15s transformed
12. STT282 iT18 stack 2x3s
13. STT282 iT21 stack 5x1s
14. STT282 iT24 stack 2x1s
15. STT282 iT24 stack 3x1s
16. STT282 iT24 stack 5x1s
17. STT282 iT24 stack 5x1s_2
18. Mean values for Sep and PA over the 9 stacked images (with a total number of 35 images) indicated above. Rms_dSep 0.224 and Sep standard deviation 0.185, rms_dPA 0.563 and PA standard deviation 0.468
19. STT297 iT18 stack 5x3s
20. STT297 iT21 stack 5x1s
21. STT297 iT24 stack 3x1s
22. STT297 iT24 stack 5x1s
23. STT297 iT24 stack 5x1s_2
24. STT297 iT24 stack 6x1s
25. Mean values for Sep and PA over the 6 stacked images (with a total number of 29 images) indicated above. Rms_dSep 0.213 and Sep standard deviation 0.086, rms_dPA 0.952 and PA standard deviation 0.112
26. STT245 iT11 stack 4x1s
27. STT245 iT18 stack 2x3s
28. STT245 iT21 stack 5x1s
29. STT245 iT24 stack 2x1s
30. STT245 iT24 stack 4x1s
31. STT245 iT24 stack 5x1s
32. Mean values for Sep and PA over the 6 stacked images (with a total number of 22 images) indicated above. Rms_dSep 0.252 and Sep standard deviation 0.027, rms_dPA 1.724 and PA standard deviation 0.221
33. STT268 iT18 stack 4x1s
34. STT268 iT24 1x1s_2
35. STT268 iT24 stack 5x1s
36. Mean values for Sep and PA over the 3 stacked images (with a total number of 10 images) indicated above. Rms_dSep 0.209 and Sep standard deviation 0.096, rms_dPA 0.628 and PA standard deviation 0.201
37. STT268 iT18 stack 4x1s
38. STT268 iT24 1x1s
39. STT268 iT24 1x1s_2
40. STT268 iT24 stack 5x1s
41. STT268 iT24 stack 5x1s_2
42. The faint and very wide D component of STT268 was present in all images but with low SNR. Mean values for Sep and PA over the 3 stacked images (with a total

number of 10 images) indicated above. Rms_dSep 0.197 and Sep standard deviation 0.162, rms_dPA 0.144 and PA standard deviation 0.106

43. STT268 iT24 1x1s
44. STT268 iT24 stack 5x1s_2
45. The very faint and close GAT2/STT268BaBb pair was present in two images but also with quite low SNR, so this result seems not very reliable. Also the potential PA error seems huge – but this is the effect of the small separation compared with the given plate solve error based separation error. Mean values for Sep and PA over the 2 stacked images (with a total number of 6 images) indicated above. Rms_dSep 0.178 and Sep standard deviation 0.096, rms_dPA 7.760 and PA standard deviation 6.676
46. STT305 iT11 stack 5x1s
47. STT305 iT18 stack 3x1s
48. STT305 iT21 stack 5x1s
49. STT305 iT24 stack 4x1s
50. STT305 iT24 stack 5x1s
51. STT305 iT24 stack 5x1s_2
52. STT305 iT24 stack 5x1s_3
53. Measurement for component B instead of bogus C. Mean values for Sep and PA over the 7 stacked images (with a total number of 35 images) indicated above. Rms_dSep 0.211 and Sep standard deviation 0.358, rms_dPA 2.184 and PA standard deviation 1.829
54. STT289 iT18 stack 5x3s
55. STT289 iT21 stack 4x4s
56. STT289 iT21 stack 5x2s
57. STT289 iT21 stack 5x1s
58. STT289 iT24 1x1s
59. STT289 iT24 1x2s
60. STT289 iT24 stack 2x1s
61. STT289 iT24 stack 5x3s
62. STT289 iT24 stack 5x4s
63. Like for photometry also for astrometry plate solving issues with the STT289 images due to the small number of reference stars in the field of view posed some challenge - with this already rather close separation small changes in plate solving results and centroid positioning had significant influence on PA. To get more reliability we had to resort to including images for astrometry calculation not used for photometry due to heavily overlapping star disks – by changing contrast and brightness and in some cases looking at the ADU numbers it was also here possible to detect the centroid rather precisely. Mean values for Sep and PA over the 9 stacked images (with a total number of 36 images) indicated above. Rms_dSep 0.207 and Sep standard deviation 0.641, rms_dPA 2.361 and PA standard deviation 2.786

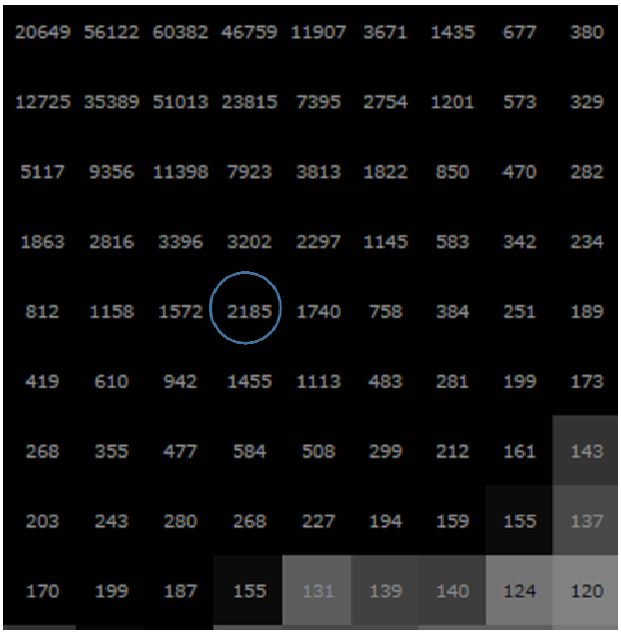


Figure 2.4.2.1: Example for centroid detection despite overlapping star disks by checking ADU numbers.

STT Doubles with Large ΔM – Part III: Vir, Ser, Com, CrB and Boo

(Continued from page 132)

3. Summary

Tables 3.1 and 3.2 below compare the final results of our research with the WDS data that was current at the time we began working on the group of stars in Boötes, Coma Bernices, Corona Borealis, Serpens, and Virgo.

In Table 3.1 the results of our photometry have been averaged for each star. Because we're aware that both the NOMAD-1 and the UCAC4 catalogs are frequently consulted when making WDS evaluations of magnitudes changes, the data from those catalogs has also been included for each of the stars. One thing that stands out on first glance at Table 3.1 is the absence of NOMAD-1 and UCAC4 data, especially with regard to the UCAC4 Vmags. As we observed in our previous papers in this series, the lack of data appears to be confirmation of the difficulties associated with magnitude determinations of high delta_M pairs.

Red type has been used in Tables 3.1 and 3.2 to call attention to significant differences from the WDS data. With regard to Table 3.1, those magnitudes that differ by two tenths of a magnitude or more from the WDS values have been highlighted. In Table 3.2 differences in separation in excess of two-tenths of an arc second are highlighted, as are all position angles which differ by more than a degree. Our results are in agreement with many of the WDS values. In regard to STT 268, see the discussion on separation and position angle data in section 2.2.

Subsequent to our measures, as a quality check for

Table 3.1: Photometry and Visual Results Compared to WDS

	WDS Mag	NOMAD-1 VMag	UCAC4 VMa	UCAC4 f. mag	Average of Photometry Measures	Results of Visual Observations
STT 247 B	13.50	-	-	13.213	13.462	No visual sighting of B, indicating it might be fainter than the WDS value.
STT 282 B	11.60	11.820	-	11.493	11.765	Two observations concluded B was half a magnitude fainter than WDS value, three concluded the WDS value was a close match.
STT 297 B	12.30	-	-	12.107	11.969	Two observations concluded B was about .3 of magnitude fainter than the WDS value; one concluded B was quite a bit brighter.
STT 245 B	10.20	-	-	-	10.727	Two observations found B very difficult, hinting it might be fainter than the WDS value; a third confirmed visual difficulty as close to what would be expected given the 4.50 delta_M.
STT 268 B	13.00	12.880	-	12.440	12.989	Three observations found B was slightly brighter than the WDS value of 13.00, one found B similar to D (fainter).
GAT 2 Ba	13.70	-	-	-	13.025	Not able to split visually.
GAT 2 Bb	13.80	-	-	-	13.116	Not able to split visually.
H 570 D	13.46	13.430	13.464	13.417	13.539	One observation found D about equal in magnitude to B.
STT 305 B	10.17	10.101	10.171	-	10.196	Difficult object; the single observation concluded B was slightly brighter than the WDS value.
STT 289 B	10.20	-	10.400	-	11.109	Difficult visual object; single observation found B was a close match to the WDS value.

Table 3.2: Astrometry Results Compared to WDS

	WDS Coordinates	WDS Sep	WDS PA	Astrometry Coordinates	Astrometry Sep	Astrometry PA
STT 247 AB	12:22:17.228 +03:17:51.600	13.80"	46°	12:22:17.009 +03:17:51.890	14.038"	46.947°
STT 282 AB	14:26:00.560 +07:13:52.601	22.70"	216°	14:26:00.445 +07:13:51.471	22.797"	216.152°
STT 297 AB	15:34:49.411 +24:59:56.697	12.30"	331°	15:34:49.502 +24:59:55.100	12.715"	332.421°
STT 245 AB	12:17:30.599 +28:56:13.599	8.30"	281°	12:17:30.53 +28:56:14.38	8.371"	281.752°
STT 268 AB	13:30:52.209 +24:14:15.299	18.20"	80°	13:30:52.208 +24:14:15.863	19.066"	77.520°
H 570 AD	Same coordinates as STT 268 AB	79.90"	27°	13:30:52.210 +24:14:15.832	78.663"	26.612°
GAT 2 Ba,Bb	13:30:53.56 +24:14:19.6	1.60"	35°	13:30:53.556 +24:14:19.405	1.307"	42.064°
STT 305 AB	16:11:39.603 +33:20:33.806	5.0"	268°	16:11:39.605 +33:20:34.189	5.529"	264.589°
STT 289 AB	14:55:58.630 +32:18:00.299	4.60"	110°	14:55:58.527 +32:18:00.071	5.021"	107.615°

our astrometry results we turned to the URAT1 catalog for the most recent precise professional measurements available. We used its coordinates to calculate the Sep and PA for all objects in this report for which URAT1 data was available and compared these values with our results as shown table 3.3.

With the exception of STT297AB, the Sep results are all within the given error range, so this comparison can be considered as confirmation for the reported results. In the case of STT297 all of the stacked images used showed very consistent results, so there is no good explanation available as to why the URAT1 based Sep result is outside the error range. However, in this case the deviation is a rather small one.

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- Washington Double Star Catalog
- iTelescope
- AAVSO VPhot
- AAVSO APASS
- UCAC4 catalog via the University of Heidelberg website and directly from USNO DVD
- Aladin Sky Atlas v8.0
- SIMBAD, VizieR
- 2MASS All Sky Catalog
- URAT1 Survey

STT Doubles with Large ΔM – Part III: Vir, Ser, Com, CrB and Boo

Table 3.3: Astrometry Results Compared with URAT1 Coordinates

Object	URAT1 Sep	iTelescope Sep	dSep	Within Error Range?	URAT1 PA	iTelescope PA	dPA	Within Error Range?
STT 247 AB	13.937	14.038	0.274	Yes	46.463	46.947	1.041	Yes
STT 282 AB	22.889	22.797	0.290	Yes	216.093	216.152	0.732	Yes
STT 297 AB	12.438	12.715	0.229	NO	332.444	332.421	0.965	Yes
STT 245 AB	8.408	8.371	0.253	Yes	281.840	281.752	1.738	Yes
STT 268 AB	18.993	19.066	0.230	Yes	77.249	77.520	0.660	Yes
H 5 70 AD	78.889	78.663	0.255	Yes	26.500	26.612	0.179	Yes

- AstroImageJ v3.0.0
- AstroPlanner v2.2
- MaxIm DL6 v6.08
- Astrometrica v4.8.2.405

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