STT Doubles with Large ΔM – Part VI: Cygnus Multiples

Wilfried R.A. Knapp
Vienna, Austria
wilfried.knapp@gmail.com

John Nanson
Star Splitters Double Star Blog
Manzanita, Oregon
jnanson@nehalemtel.net

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. Of these objects we found three rather complex multiples in Cygnus of special interest so we decided to write a separate report to have more room to include the non STT components as well. Again like for the other objects covered so far several of the components show parameters quite different from the current WDS data.

Change in Procedure

With the availability of URAT1 for plate solving in the northern skies we decided to switch from UCAC4 to URAT1 to get results of higher precision and avoid problems with proper motion issues. We changed further the plate solving setup from Linear Fit to 4th-Order Fit resulting in a substantial reduction of the average plate solving error due to better adaption to the Corrected Dell-Kirkham optics used for imaging.

Introduction

As follow up to our previous STT reports, we continue in the constellation of Cygnus with 3 multiples with a rather complex structure (see Table 1). All values are based on WDS data as of the beginning of 2016.

Further Research

Following the procedure for the earlier parts 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.

Historical Research and Catalog Comparisons

Each of the three multiple stars in this survey have notable aspects worth further investigation. Three main research sources were used for this section of this paper, the first of which was W.J. Hussey's *Micrometrical Observations of the Double Stars Discovered at Pulkowa*, published in 1901, which provided 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 data beginning with the date of first measure and continuing through the following years up to 1900. That data, plus inclusion of the background for the Pulkovo Catalog, makes Hussey's book a valuable source of reference. Also consulted was S.W. Burnham's *A General Catalogue of Double Stars Within 121° of the North Pole, Part II*, for information on each of the three stars. In addition, Bill Hartkopf of the USNO graciously provided the text files for 425 and STT 433.

STT 425 Otto Struve measured the first two discovered components of STT 425 in 1847 (27.7° and 12.18"), which he designated AB. However S.W. Burnham discovered a much closer companion in 1890 (119.9° and 2.30") with the Lick 36 inch refractor (also observed by Hussey with the Lick 12 inch refractor), and that pair became the new AB, while the pair Otto Struve discovered became AC. The star now designat-

Table 1. WDS catalog Data at the Beginning of 2016 for the Selected STT Objects

Name		ID	RA	Dec	Sep	PA	M1	M2	ΔM
BU449	AB	21395+4144	21:39:28.710	+41:43:36.00	6.2	14	7.67	12.70	5.03
STT447	AC	21395+4144	21:39:28.710	+41:43:36.00	13.7	176	7.67	12.20	4.53
BU449	AD	21395+4144	21:39:28.710	+41:43:36.00	18.7	248	7.67	13.00	5.33
STT447	AE	21395+4144	21:39:28.710	+41:43:36.00	28.6	45	7.67	8.48	0.81
ABH148	AG	21395+4144	21:39:28.710	+41:43:36.00	33.8	337	7.67	14.80	7.13
ABH148	AH	21395+4144	21:39:28.710	+41:43:36.00	74.2	263	7.67	13.79	6.12
ABH148	AI	21395+4144	21:39:28.710	+41:43:36.00	92.7	271	7.67	11.65	3.98
ABH148	AJ	21395+4144	21:39:28.710	+41:43:36.00	71.3	94	7.67	13.88	6.21
ABH148	AK	21395+4144	21:39:28.710	+41:43:36.00	75.0	49	7.67	11.65	3.98
FOX262	EF	21395+4144	21:39:30.520	+41:43:36.00	42.0	46	8.48	11.56	3.08
STT433	AB	21179+3454	21:17:55.070	+34:53:48.80	14.2	222	4.36	10.00	5.64
STT433	AC	21179+3454	21:17:55.070	+34:53:48.80	21.2	181	4.36	9.95	5.59
SLE382	AD	21179+3454	21:17:55.070	+34:53:48.80	57.0	308	4.36	12.00	7.64
BU9011	AE	21179+3454	21:17:55.070	+34:53:48.80	34.2	67	4.36	10.00	5.64
STT433	BC	21179+3454	21:17:54.290	+34:53:37.10	10.1	141	10.00	10.00	0.00
BU1210	AB	21001+4841	21:00:06.610	+48:40:45.90	1.4	104	7.34	12.20	4.86
STT425	AC	21001+4841	21:00:06.610	+48:40:45.90	17.9	27	7.34	10.80	3.46
STT425	AE	21001+4841	21:00:06.610	+48:40:45.90	44.9	16	7.34	10.61	3.27
STT425	CD	21001+4841	21:00:07.409	+48:41:01.707	4.5	132	10.5	10.90	0.40

ed as the D component was discovered by Struve in 1851, which he measured from the star he had previously designated as B (now C) at a position angle of 135°, but didn't include a separation, although Hussey (1901, p. 174) includes a comment that Struve came up with a distance of 4.11". That leaves the E component, which was first measured by S.W. Burnham in 1898 at 18° and 45.17".

The last two measures of the AB pair discovered in 1890 by Burnham were made in 1924 and shows a surprising difference in position angle and separation, as seen in Table 2. We were able to track down the publication containing the 1924.900 measure, verified the data listed in the WDS text file matched the published data, and also found it was made using the 28 inch refractor at Greenwich by R.T. Cullen. Because of the 4.86 magnitude differential between the two components, the secondary is so well hidden in the glare of the primary that it has not been detected in the numerous photographic surveys we've checked (NOMAD-1, UCAC4, URAT1, Hipparcos, GSC 2.3, Tycho, and USNO A-2 and B-1). Our efforts at photographing the secondary met with the same results. A new measure of the AB pair would be welcome if for no other reason than to verify that the 1924.900 PA is an anomaly.

A comparison of the various components of STT 425 shows very little change in PA and separation with the exception of the AC pair (Table 3). Since O. Struve's 1847 discovery, the pair has widened from 12.18" to 17.85" as of the most recent measure in the WDS (2003). Our measure for the pair was 18.142",

Table 2. Data for STT 425 AB (BU 1210) from the WDS

Date	PA	Sep
1890.630	119.9	2.30
1898.420	117.2	2.35
1898.600	120.2	2.54
1901.623	117.2	2.40
1903.550	118.6	2.03
1924.810.	117.1	2.24
1924.900	103.9	1.43

Table 3. Data for STT 425 AC from the WDS

Date	PA	Sep
1847.490	27.7	12.18
1867.000	29.9	12.72
1868.430	29.7	12.81
1890.630	28.6	13.80
1898.450	28.0	13.80
1898.548	45.2	13.37
1898.582	46.8	13.55
1898.600	28.0	13.98
1900.640	26.9	14.35
1901.623	27.8	14.13
1902.540	28.4	14.33
1903.570	29.1	14.08
1907.880	28.2	14.44
1924.810	27.4	14.91
1999.470	26.7	17.79
2000.690	27.6	17.53
2003.488	26.9	17.85

which indicates the separation has continued to widen.

The two position angles of 1898.548 and 1898.582 stand out as anomalous in the data in Table 3. The WDS text file shows those measures were made by Hussey and are from his 1901 book used as a reference for this paper. A look at Hussey's data on p. 174 of that book shows three 1898 measures with PA's of 28.1°, 29.2°, and 28.4°, which average out to the 28.6° number he lists in the book for 1898.57. His three 1898 separation measures were 14.10", 13.97", and 13.92", which average out to the 14.0" number listed in the book for the 1898.57 date. Consequently it appears the PA's of 45.2° and 46.8° in the WDS text file are incorrect.

STT 433 (Upsilon Cygni) This is a complex multiple star with a complex past, comprised of five components and two additional WDS designations beyond STT 433: SLE 382 for the AD pair and BU 9011 for the AE pair.

The AB pair was first seen by John Herschel in 1827, who provided estimated measures of 210° and 21". Otto Struve added the first specific measures in 1849, which were 219.4° and 14.91". John Herschel was also the first to look at the AC components, again in 1827, and again estimated the measures (180° and 30"), followed by Otto Struve with actual measures in 1849 (177.6° and 21.16"). The AD/SLE 382 pair is credited to G. Soulie, but the WDS text file data shows it was first noticed by Philip Fox in 1912. However, our search through the WDS source could only turn up this short comment by Fox: "Star (12.5) in 309° : 1' " (Fox, 1915, p. 199). Soulie's astrographic measures were made in 1982 according to the text file, and it appears Fox's observation was added to the WDS after 2006.

The component which is now designated as E was first noticed by S.W. Burnham in 1874 (Burnham, 1874, p. 46). He estimated the distance and PA of what is now the AE pair, and repeated those comments in his 1906 catalog (shown in Figure 1, where he used a designation of D). It appears he never returned to make specific measures of the two stars. The out of sequence 9011 number was added by the WDS at some point after 2006. (A first look at the 1874 source referred to in the WDS text file failed to turn up Burnham's observation, but a closer look at the MNRAS titles in the SAO/NASA ADS catalog led to the discovery that Burnham's article had been split into two parts, with the second part listed under an erroneous title. We've included both ADS bibliographic codes in the sources section of this paper.).

STT 447 With a total of eleven components you almost need a scorecard to keep track of all the members of this system, especially since the designations have been frequently revised as new components were added. Table 4 shows the designations in use in 1898 when Hussey published his *Micrometrical Observations of the Double Stars Discovered at Pulkowa* and the changes made in 1906 by Burnham (which are also the designations currently used in the WDS) in his *General Catalogue of Double Stars*.

The observational history of STT 447 goes back to September 17, 1783, when William Herschel cataloged it as H III 110. He measured what are now the AC and AE pairs, but also described H III 110 as quadruple. Although he didn't provide any measures for it, the fourth star to which he referred – "Position almost in line with the two largest." (Herschel, 1784, p. 90) – can

No. 289 (Triple).

R.A. = 21h 13m 22s		Decl. = + 34° 25′	
A and B	P = 140° ±	D = 1″	A = 8½ m.
A and C	270° ±	5″	B = 10 m.

This fine triple is in the field with *υ Cygni* (OΣ 43) 24s following, and 1′ 43″ north. The close pair was subsequently seen perfectly at Hanover, and from a casual observation, I think my 6-in. will at least make the elongation obvious. The third star is very small, even with the great telescope. This star is Weisse XXI. 289. *υ Cygni* has a third companion D in the direction of 60°, at a little less then twice the distance of the companion C of the *Pulkowa Catalogue*.

from

A Fifth Catalogue of 71 New Double Stars by S.W. Burnham, p.46

Figure 1. Burnham's entry for STT 433.A

Table 4. Changes in STT 447 Designations Between 1898 and 1906

Hussey Designation	Current Designation
AD	AB
AC	AC
AE	AD
AB	AE

be identified by looking at Figure 2, where AB and E (Herschel's two "largest" stars) are in line with the star now labeled as F.

In addition to the STT 447 designation, there are three more WDS designations within the group. S.W. Burnham discovered and measured the B and D components in 1876 with the 18 ½ inch refractor at the Dearborn Observatory. The AB and AD pairs are designated as BU 449. Philip Fox brought William Herschel's fourth star into the system in 1895 when he measured the distance and position angle between it and the E component, resulting in EF being designated as Fox 262.

That leaves the last five components, G through K, which were added in 1987 by H.A.Abt, although the first measures of the AI and AK pairs appear to have been made from photographic plates since the WDS date of first measure is 1895. The AG, AH, AI, AJ, and AK pairs are all designated as ABH 148.

There has been very little change in the separations of the eleven components of this system, which is not surprising considering the distance of STT 447 A is 815 light years. The WDS Catalog assigns a code of "U" to each of the STT 447 components, which characterizes all members as non-physical.

Visual Observations

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

STT 425 (Cyg): Knapp looked at STT 425 twice. During the first observation, using the masking device he could detect C with the aperture limited to 60mm, suggesting it's slightly brighter than the WDS value of 10.80. The limiting aperture during the second observation was 80mm, which would indicate a confirmation of the WDS magnitude. Nanson observed STT 425 once with the six inch refractor and found C (10.80) and E (WDS magnitude 10.61) appeared to be about the same magnitude, both of which were slightly brighter than a comparison star with a Vmag of 11.586, indicating the WDS magnitudes are about right.

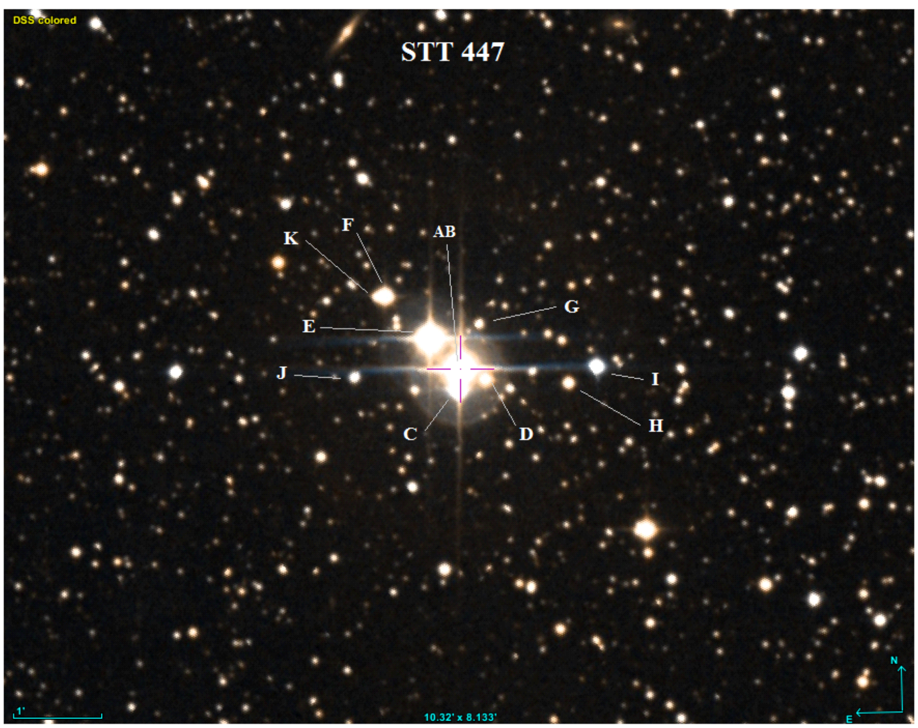

Figure 2. Aladin image of STT 447 with all components labeled.

The CD pair (separation of 4.5", WDS magnitudes of 10.80 and 10.90) were resolved at 152x and 304x. D appeared to be about half a magnitude fainter than C. It was obvious the CD pair is not the evenly matched pair indicated by the WDS magnitudes.

STT 433 (Cyg): Nanson observed STT 433 once and was able to see B and C clearly at 84x, but lost both of them in the glare of the primary when adding additional magnification because of poor seeing conditions. Both of those stars were close matches for a comparison star with a Vmag of 9.901, suggesting their WDS magnitudes (10.0 and 9.95, respectively) should be reasonably close. He spent several minutes searching for D and finally saw it at 253x with averted vision, leading to the conclusion that it may be close to 13^{th} magnitude since it should have been easier to see if the WDS magnitude of 12.0 is correct. He searched repeatedly for E, but never saw it, suggesting the WDS magnitude of 10.0 is incorrect.

Knapp observed STT 433 twice. During the first observation he could detect B at 200x with the aperture reduced to 93mm, suggesting B is at least half a magnitude fainter than the WDS's 10.0. C could be seen at 200x with the aperture reduced to 80mm, also suggesting it may be half a magnitude fainter than the WDS's 9.95. During the second observation, B was visible at 180x with the aperture reduced to 90mm, again suggesting it may be fainter than the WDS value of 10.0.

STT 447 (Cyg): Knapp observed this complex multiple star twice. Using the aperture mask, each time he found C appeared to be about a magnitude brighter than the WDS value of 12.20. Nanson looked at STT 447 once during conditions of poor transparency. Using magnifications of 152x and 253x on the six inch refractor, he also found C to be about a magnitude brighter than the WDS value based on comparison with the 11.56 magnitude F component. C was a bit easier to see than I (WDS magnitude of 11.65).

Looking at the other components, he concluded the WDS magnitude of the I component is correct or very close to correct based on a comparison star with a Vmag of 11.244. The I component seemed to be fainter than 11.56 magnitude F, but the combined brightness of F and K (WDS value of 11.65) very likely makes F appear brighter than it is (K was hidden in the glare of F). D was glimpsed once with averted vision – given the poor transparency, it's possible D is slightly brighter than the WDS value of 13.0.

Photometry and Astrometry Results

Several hundred images taken with iTelescope remote telescopes were in a first step plate solved and stacked with AAVSO VPhot. The stacked images were then plate solved with Astrometrica with URAT1 reference stars with Vmags in the range 10.5 to 14.5mag. The RA/Dec coordinates resulting from plate solving with URAT1 reference stars in the 10.5 to 14.5mag range were used to calculate Sep and PA using the formula provided by R. Buchheim (2008). Err_Sep is calculated as SQRT(dRA^2+dSep^2) with dRA and dDec as average RA and Dec plate solving errors. Err_PA is the error estimation for PA calculated as arctan (Err_Sep/Sep) in degrees assuming the worst case that Err_Sep points in the right angle to the direction of the separation means perpendicular to the separation vector. Mag is the photometry result based on UCAC4 reference stars with Vmags between 10.5 and 14.5mag. Err_Mag is calculated as square root of (dVmag^2 + (2.5*Log10(1+1/SNR))^2) with dVmag as the average Vmag error over all used reference stars and SNR is the signal to noise ratio for the given star. The results are shown in Table 5.

Summary

Tables 6 and 7 compare the final results of our research with the WDS data that was current at the time we began working on our current group of stars.

In Table 6 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.

Red type has been used in Tables 6 and 7 to call attention to significant differences from the WDS data. With regard to Table 6, those magnitudes that differ by two tenths of a magnitude or more from the WDS values have been highlighted. In Table 7 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.

Subsequent to our measures, as a quality check for 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, which are shown below in Table 8.

Acknowledgements

The following tools and resources have been used for this research:

- Washington Double Star Catalog as data source for the selected objects
- iTelescope: Images were taken with

(Continued on page 534)

STT Doubles with Large ΔM – Part VI: Cygnus Multiples

Table 5. Photometry and astrometry results for the selected STT objects. Date is the Bessel epoch in 2015 and N is the number of images (usually with 1s exposure time) used for the reported values. iT in the Notes column indicates the telescope used with number of images and exposure time given (Specifications of the used telescopes: See Acknowledgements). The average results over all used images are given in the line below the individual stacks in red and bold. The error estimation over all used images is calculated as root mean square over the individual Err values. The N column in the summary line gives the total number of images used and Date the average Bessel epoch.

BU 449	RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
A	21 39 28.727	41 43 36.03	0.06	0.06	6.042	0.085	13.718	0.805	7.475	0.070	339.58	0.07	621	5	1
B	21 39 28.855	41 43 41.90							12.662	0.099	14.97				
A	21 39 28.727	41 43 36.04	0.05	0.04	5.974	0.064	13.878	0.614	7.491	0.050	400.85	0.05	632	5	2
B	21 39 28.855	41 43 41.84							12.480	0.080	17.00				
A	21 39 28.723	41 43 36,04	0.07	0.05	6.073	0.086	14.084	0.812	7.494	0.080	284.05	0.08	639	5	3
B	21 39 28.855	41 43 41.93							12.733	0.105	15.34				
A	**21 39 28.726**	**41 43 36.04**	**0.061**	**0.051**	**6.030**	**0.079**	**13.894**	**0.750**	**7.487**	**0.068**			**630**	**15**	4
B	**21 39 28.855**	**41 43 41.89**							**12.625**	**0.095**					
STT 447	**RA**	**Dec**	**dRA**	**dDec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**SNR**	**dVmag**	**Date**	**N**	**Notes**
A	21 39 28.727	41 43 36.03	0.06	0.06	14.035	0.085	176.570	0.346	7.475	0.070	339.58	0.07	621	5	5
C	21 39 28.802	41 43 22.02							11.204	0.071	102.48				
A	21 39 28.727	41 43 36.04	0.05	0.04	14.078	0.064	176.398	0.261	7.491	0.050	400.85	0.05	632	5	6
C	21 39 28.806	41 43 21.99							11.222	0.051	102.83				
A	21 39 28.729	41 43 35.84	0.08	0.10	14.027	0.128	176.477	0.523	7.291	0.090	309.59	0.09	700	5	7
C	21 39 28.806	41 43 21.84							11.140	0.091	69.08				
A	21 39 28.723	41 43 36,04	0.07	0.05	14.079	0.086	176.307	0.350	7.494	0.080	284.05	0.08	639	5	8
C	21 39 28.804	41 43 21.99							11.167	0.083	52.78				
A	**21 39 28.727**	**41 43 35.99**	**0.066**	**0.067**	**14.055**	**0.094**	**176.438**	**0.382**	**7.438**	**0.074**			**648**	**20**	9
C	**21 39 28.805**	**41 43 21.96**							**11.183**	**0.075**					
BU 449	**RA**	**Dec**	**dRA**	**dDec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**SNR**	**dVmag**	**Date**	**N**	**Notes**
A	21 39 28.727	41 43 36.03	0.06	0.06	18.946	0.085	247.894	0.257	7.475	0.070	339.58	0.07	621	5	5
D	21 39 27.159	41 43 28.90							13.120	0.075	42.06				
A	21 39 28.727	41 43 36.04	0.05	0.04	18.949	0.064	247.963	0.194	7.491	0.050	400.85	0.05	632	5	6
D	21 39 27.158	41 43 28.93							13.091	0.057	40.65				
A	21 39 28.729	41 43 35.84	0.08	0.10	18.937	0.128	248.144	0.387	7.291	0.090	309.59	0.09	700	5	7
D	21 39 27.159	41 43 28.79							13.127	0.100	24.88				
A	21 39 28.723	41 43 36,04	0.07	0.05	18.962	0.086	247.782	0.260	7.494	0.080	284.05	0.08	639	5	10
D	21 39 27.155	41 43 28.87							13.144	0.097	19.52				
A	**21 39 28.727**	**41 43 35.99**	**0.066**	**0.067**	**18.949**	**0.094**	**247.945**	**0.283**	**7.438**	**0.074**			**648**	**20**	9
D	**21 39 27.158**	**41 43 28.87**							**13.121**	**0.084**					

Table 5 continues on next page.

Table 5 (continued). Photometry and astrometry results for the selected STT objects. ...

STT 447	RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
A	21 39 28.727	41 43 36.03	0.06	0.06	29.142	0.085	44.206	0.167	7.475	0.070	339.58	0.07	621	5	11
E	21 39 30.542	41 43 56.92							8.453	0.070	341.74				
A	21 39 28.727	41 43 36.04	0.05	0.04	28.956	0.064	44.565	0.127	7.491	0.050	400.85	0.05	632	5	12
E	21 39 30.542	41 43 56.67							8.459	0.050	318.26				
A	21 39 28.729	41 43 35.84	0.08	0.10	28.976	0.128	44.464	0.253	7.291	0.090	309.59	0.09	700	5	13
E	21 39 30.542	41 43 56.52							8.275	0.090	242.38				
A	21 39 28.723	41 43 36,04	0.07	0.05	28.971	0.086	44.566	0.170	7.494	0.080	284.05	0.08	639	5	14
E	21 39 30.539	41 43 56.68							8.459	0.080	184.05				
A	21 39 28.727	41 43 35.99	0.066	0.067	29.011	0.094	44.450	0.185	7.438	0.074			648	20	15
E	21 39 30.541	41 43 56.70							8.412	0.074					
ABH 148	**RA**	**Dec**	**dRA**	**dDec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**SNR**	**dVmag**	**Date**	**N**	**Notes**
A	21 39 28.727	41 43 36.03	0.06	0.06	33.841	0.085	336.611	0.144	7.475	0.070	339.58	0.07	621	5	16
G	21 39 27.527	41 44 07.09							14.598	0.106	13.22				
A	21 39 28.727	41 43 36.04	0.05	0.04	33.784	0.064	336.321	0.109	7.491	0.050	400.85	0.05	632	5	17
G	21 39 27.515	41 44 06.98							14.766	0.095	12.91				
A	21 39 28.729	41 43 35.84	0.08	0.10	33.658	0.128	336.601	0.218	7.291	0.090	309.59	0.09	700	5	18
G	21 39 27.535	41 44 06.73							14.798	0.153	8.26				
A	21 39 28.723	41 43 36,04	0.07	0.05	33.744	0.086	336.561	0.146	7.494	0.080	284.05	0.08	639	5	19
G	21 39 27.524	41 44 07.00							14.308	0.128	10.44				
A	21 39 28.727	41 43 35.99	0.066	0.067	33.757	0.094	336.523	0.159	7.438	0.074			648	20	20
G	21 39 27.525	41 44 06.95							14.618	0.122					
ABH 148	**RA**	**Dec**	**dRA**	**dDec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**SNR**	**dVmag**	**Date**	**N**	**Notes**
A	21 39 28.727	41 43 36.03	0.06	0.06	74.460	0.085	262.476	0.065	7.475	0.070	339.58	0.07	621	5	21
H	21 39 22.133	41 43 26.28							13.782	0.081	26.61				
A	21 39 28.727	41 43 36.04	0.05	0.04	74.346	0.064	262.550	0.049	7.491	0.050	400.85	0.05	632	5	22
H	21 39 22.142	41 43 26.40							13.733	0.064	27.19				
A	21 39 28.731	41 43 35.87	0.08	0.10	74.434	0.128	262.768	0.099	7.291	0.090	309.59	0.09	700	5	23
H	21 39 22.135	41 43 26.50							14.055	0.112	15.68				
A	21 39 28.723	41 43 36,04	0.07	0.05	74.373	0.086	262.459	0.066	7.494	0.080	284.05	0.08	639	5	24
H	21 39 22.137	41 43 26.28							13.885	0.117	12.21				
A	21 39 28.727	41 43 36.00	0.066	0.067	74.403	0.094	262.563	0.072	7.438	0.074			648	20	25
H	21 39 22.137	41 43 26.37							13.864	0.096					

Table 5 continues on next page.

STT Doubles with Large ΔM – Part VI: Cygnus Multiples

Table 5 (continued). Photometry and astrometry results for the selected STT objects. ...

ABH 148	RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
A	21 39 28.727	41 43 36.03	0.06	0.06	92.952	0.085	271.270	0.052	7.475	0.070	339.58	0.07	621	5	5
I	21 39 20.426	41 43 38.09							12.033	0.072	68.15				
A	21 39 28.727	41 43 36.04	0.05	0.04	92.883	0.064	271.234	0.039	7.491	0.050	400.85	0.05	632	5	6
I	21 39 20.432	41 43 38.04							12.056	0.052	72.26				
A	21 39 28.729	41 43 35.84	0.08	0.10	92.908	0.128	271.283	0.079	7.291	0.090	309.59	0.09	700	5	7
I	21 39 20.432	41 43 37.92							12.050	0.093	43.32				
A	21 39 28.723	41 43 36,04	0.07	0.05	92.839	0.086	271.241	0.053	7.494	0.080	284.05	0.08	639	5	8
I	21 39 20.432	41 43 38.05							12.036	0.086	34.96				
A	21 39 28.727	41 43 35.99	0.066	0.067	92.895	0.094	271.257	0.058	7.438	0.074			648	20	9
I	21 39 20.430	41 43 38.03							12.044	0.077					
ABH 148	**RA**	**Dec**	**dRA**	**dDec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**SNR**	**dVmag**	**Date**	**N**	**Notes**
A	21 39 28.727	41 43 36.03	0.06	0.06	71.110	0.085	94.654	0.068	7.475	0.070	339.58	0.07	621	5	5
J	21 39 35.058	41 43 30.26							13.989	0.086	21.60				
A	21 39 28.727	41 43 36.04	0.05	0.04	71.139	0.064	94.499	0.052	7.491	0.050	400.85	0.05	632	5	6
J	21 39 35.062	41 43 30.46							13.874	0.065	25.34				
A	21 39 28.729	41 43 35.84	0.08	0.10	71.149	0.128	94.369	0.103	7.291	0.090	309.59	0.09	700	5	26
J	21 39 35.066	41 43 30.42							14.053	0.124	12.34				
A	21 39 28.723	41 43 36,04	0.07	0.05	71.207	0.086	94.503	0.069	7.494	0.080	284.05	0.08	639	5	27
J	21 39 35.064	41 43 30.45							14.037	0.130	10.13				
A	21 39 28.727	41 43 35.99	0.066	0.067	71.151	0.094	94.506	0.075	7.438	0.074			648	20	28
J	21 39 35.062	41 43 30.40							13.988	0.105					
ABH 148	**RA**	**Dec**	**dRA**	**dDec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**SNR**	**dVmag**	**Date**	**N**	**Notes**
A	21 39 28.727	41 43 36.03	0.06	0.06	74.588	0.085	48.760	0.065	7.475	0.070	339.58	0.07	621	5	29
K	21 39 33.737	41 44 25.20							15.715	0.215	4.86				
A	21 39 28.727	41 43 36.04	0.05	0.04	74.679	0.064	48.667	0.049	7.491	0.050	400.85	0.05	632	5	30
K	21 39 33.736	41 44 25.36							15.486	0.150	7.19				
A	21 39 28.723	41 43 36,04	0.07	0.05	74.946	0.086	48.358	0.066	7.494	0.080	284.05	0.08	639	5	31
K	21 39 33.726	41 44 25.84							15.577	0.315	3.09				
A	21 39 28.726	41 43 36.04	0.061	0.051	74.737	0.079	48.595	0.061	7.487	0.068			630	15	32
K	21 39 33.733	41 44 25.47							15.593	0.236					

Table 5 continues on next page.

Table 5 (continued). Photometry and astrometry results for the selected STT objects. ...

FOX 262	RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
E	21 39 30.542	41 43 56.92	0.06	0.06	41.529	0.085	46.341	0.117	8.453	0.070	341.74	0.07	621	5	5
F	21 39 33.226	41 44 25.59							11.611	0.071	87.57				
E	21 39 30.542	41 43 56.67	0.05	0.04	41.708	0.064	46.062	0.088	8.459	0.050	318.26	0.05	632	5	6
F	21 39 33.225	41 44 25.61							11.621	0.051	89.24				
E	21 39 30.542	41 43 56.52	0.08	0.10	41.778	0.128	45.984	0.176	8.275	0.090	242.38	0.09	700	5	7
F	21 39 33.226	41 44 25.55							11.562	0.092	57.53				
E	21 39 30.539	41 43 56.68	0.07	0.05	41.739	0.086	46.084	0.118	8.459	0.080	184.05	0.08	639	5	8
F	21 39 33.225	41 44 25.63							11.590	0.084	43.54				
E	21 39 30.541	41 43 56.70	0.066	0.067	41.688	0.094	46.117	0.129	8.412	0.074			648	20	33
F	21 39 33.225	41 44 25.60							11.596	0.076					
STT 433	**RA**	**Dec**	**dRA**	**dDec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**SNR**	**dVmag**	**Date**	**N**	**Notes**
A	21 17 55.096	34 53 49.05	0.03	0.03	15.342	0.042	219.488	0.158	6.239	0.051	126.84	0.05	621	5	5
B	21 17 54.303	34 53 37.21							10.818	0.051	125.30				
A	21 17 55.082	34 53 48.83	0.04	0.04	15.039	0.057	219.527	0.216	6.037	0.051	99.15	0.05	632	5	6
B	21 17 54.304	34 53 37.23							10.829	0.051	107.40				
A	21 17 55.102	34 53 48.83	0.06	0.05	15.220	0.078	220.170	0.294	4.684	0.070	657.46	0.07	639	5	7
B	21 17 54.304	34 53 37.20							10.803	0.072	58.41				
A	21 17 55.059	34 53 48.99	0.07	0.10	15.111	0.122	217.987	0.463	5.126	0.100	217.38	0.10	700	5	8
B	21 17 54.303	34 53 37.08							10.674	0.101	65.29				
A	21 17 55.085	34 53 48.93	0.052	0.061	15.177	0.081	219.295	0.304	5.522	0.071			648	20	34
B	21 17 54.303	34 53 37.18							10.781	0.072					
STT 433	**RA**	**Dec**	**dRA**	**dDec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**SNR**	**dVmag**	**Date**	**N**	**Notes**
A	21 17 55.096	34 53 49.05	0.03	0.03	22.173	0.042	183.977	0.110	6.239	0.051	126.84	0.05	621	5	5
C	21 17 54.971	34 53 26.93							10.654	0.051	140.12				
A	21 17 55.082	34 53 48.83	0.04	0.04	21.922	0.057	183.539	0.148	6.037	0.051	99.15	0.05	632	5	6
C	21 17 54.972	34 53 26.95							10.665	0.051	120.34				
A	21 17 55.102	34 53 48.83	0.06	0.05	21.981	0.078	184.269	0.204	4.684	0.070	657.46	0.07	639	5	7
C	21 17 54.969	34 53 26.91							10.659	0.072	69.15				
A	21 17 55.059	34 53 48.99	0.07	0.10	22.225	0.122	182.729	0.315	5.126	0.100	217.38	0.10	700	5	8
C	21 17 54.973	34 53 26.79							10.440	0.101	96.94				
A	21 17 55.085	34 53 48.93	0.052	0.061	22.074	0.081	183.627	0.209	5.522	0.071			648	20	34
C	21 17 54.971	34 53 26.90							10.605	0.071					

Table 5 continues on next page.

STT Doubles with Large ΔM – Part VI: Cygnus Multiples

Table 5 (continued). Photometry and astrometry results for the selected STT objects. ...

SLE 382	RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
A	21 17 55.096	34 53 49.05	0.03	0.03	57.146	0.042	306.973	0.043	6.239	0.051	126.84	0.05	621	5	5
D	21 17 51.385	34 54 23.42							13.086	0.054	51.53				
A	21 17 55.082	34 53 48.83	0.04	0.04	57.134	0.057	307.222	0.057	6.037	0.051	99.15	0.05	632	5	6
D	21 17 51.384	34 54 23.39							13.099	0.055	45.48				
A	21 17 55.102	34 53 48.83	0.06	0.05	57.286	0.078	307.056	0.078	4.684	0.070	657.46	0.07	639	5	7
D	21 17 51.386	34 54 23.35							13.020	0.085	21.66				
A	21 17 55.059	34 53 48.99	0.07	0.10	56.814	0.122	307.125	0.123	5.126	0.100	217.38	0.10	700	5	8
D	21 17 51.377	34 54 23.28							13.186	0.109	25.09				
A	21 17 55.085	34 53 48.93	0.052	0.061	57.095	0.081	307.094	0.081	5.522	0.071			648	20	34
D	21 17 51.383	34 54 23.36							13.098	0.079					

BU 9011	RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
A	21 17 55.096	34 53 49.05	0.03	0.03	34.270	0.042	67.526	0.071	6.239	0.051	126.84	0.05	621	5	5
E	21 17 57.670	34 54 02.15							13.678	0.058	36.95				
A	21 17 55.082	34 53 48.83	0.04	0.04	34.468	0.057	67.267	0.094	6.037	0.051	99.15	0.05	632	5	6
E	21 17 57.666	34 54 02.15							13.674	0.058	36.95				
A	21 17 55.102	34 53 48.83	0.06	0.05	34.241	0.078	67.216	0.131	4.684	0.070	657.46	0.07	639	5	35
E	21 17 57.668	34 54 02.09							13.799	0.104	13.50				
A	21 17 55.059	34 53 48.99	0.07	0.10	34.661	0.122	67.668	0.202	5.126	0.100	217.38	0.10	700	5	36
E	21 17 57.665	34 54 02.16							13.696	0.116	17.92				
A	21 17 55.085	34 53 48.93	0.052	0.061	34.410	0.081	67.420	0.134	5.522	0.071			648	20	34
E	21 17 57.667	34 54 02.14							13.712	0.088					

STT 433	RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
B	21 17 54.303	34 53 37.21	0.03	0.03	13.161	0.042	141.359	0.185	10.818	0.051	125.30	0.05	621	5	5
C	21 17 54.971	34 53 26.93							10.654	0.051	140.12				
B	21 17 54.304	34 53 37.23	0.04	0.04	13.115	0.057	141.403	0.247	10.829	0.051	107.40	0.05	632	5	6
C	21 17 54.969	34 53 26.98							10.665	0.051	120.34				
B	21 17 54.304	34 53 37.20	0.06	0.05	13.146	0.078	141.512	0.340	10.803	0.018	58.41	0.07	639	5	8
C	21 17 54.969	34 53 26.91							10.659	0.072	69.15				
B	21 17 54.303	34 53 37.08	0.07	0.10	13.185	0.122	141.302	0.530	10.674	0.017	65.29	0.10	700	5	7
C	21 17 54.973	34 53 26.79							10.440	0.101	96.94				
B	21 17 54.303	34 53 37.18	0.052	0.061	13.152	0.081	141.394	0.351	10.781	0.038			648	20	
C	21 17 54.971	34 53 26.90							10.605	0.071					

Table 5 concludes on next page.

STT Doubles with Large ΔM – Part VI: Cygnus Multiples

Table 5 (conclusion). Photometry and astrometry results for the selected STT objects. ...

STT 425	RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
A	21 00 06.628	48 40 45.91	0.07	0.10	18.171	0.122	27.142	0.385	7.111	0.100	383.39	0.10	700	5	7
C	21 00 07.465	48 41 02.08							10.753	0.101	85.82				
A	21 00 06.627	48 40 46.11	0.09	0.06	18.162	0.108	27.227	0.341	7.251	0.070	292.92	0.07	639	5	9
C	21 00 07.466	48 41 02.26							10.860	0.072	59.83				
A	21 00 06.634	48 40 46.06	0.06	0.06	18.149	0.085	27.143	0.268	7.301	0.050	368.32	0.05	615	5	5
C	21 00 07.470	48 41 02.21							10.902	0.051	106.91				
A	21 00 06.628	48 40 46.12	0.06	0.06	18.113	0.085	27.201	0.268	7.287	0.040	308.64	0.04	620	5	6
C	21 00 07.464	48 41 02.23							10.902	0.041	102.75				
A	21 00 06.635	48 40 46.05	0.08	0.07	18.175	0.106	27.100	0.335	7.287	0.040	393.42	0.04	632	5	37
C	21 00 07.471	48 41 02.23							10.893	0.041	110.29				
A	21 00 06.630	48 40 46.05	0.073	0.072	18.154	0.102	27.163	0.323	7.247	0.064			641	25	9
C	21 00 07.467	48 41 02.20							10.862	0.065					
BU 1210	**RA**	**Dec**	**dRA**	**dDec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**SNR**	**dVmag**	**Date**	**N**	**Notes**
A	21 00 06.630	48 40 46.05	0.073	0.072	-	-	-	-	7.247	0.064			641	25	38
B	-	-							-	-					
STT 425	**RA**	**Dec**	**dRA**	**dDec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**SNR**	**dVmag**	**Date**	**N**	**Notes**
A	21 00 06.628	48 40 45.91	0.07	0.10	45.379	0.122	15.728	0.154	7.111	0.100	383.39	0.10	700	5	7
E	21 00 07.870	48 41 29.59							10.595	0.101	93.94				
A	21 00 06.627	48 40 46.11	0.09	0.06	45.372	0.108	15.834	0.137	7.272	0.070	292.92	0.07	639	5	8
E	21 00 07.877	48 41 29.76							10.928	0.072	57.76				
A	21 00 06.634	48 40 46.06	0.06	0.06	45.380	0.085	15.779	0.107	7.301	0.050	368.32	0.05	615	5	5
E	21 00 07.880	48 41 29.73							10.884	0.051	118.04				
A	21 00 06.628	48 40 46.12	0.06	0.06	45.269	0.085	15.885	0.107	7.287	0.040	308.64	0.04	620	5	6
E	21 00 07.879	48 41 29.66							10.901	0.041	124.96				
A	21 00 06.635	48 40 46.05	0.08	0.07	45.383	0.106	15.792	0.134	7.287	0.040	393.42	0.04	632	5	35
E	21 00 07.882	48 41 29.72							10.925	0.041	120.64				
A	21 00 06.630	48 40 46.05	0.073	0.072	45.356	0.102	15.804	0.129	7.252	0.064			641	25	9
E	21 00 07.878	48 41 29.69							10.847	0.065					
STT 425	**RA**	**Dec**	**dRA**	**dDec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**SNR**	**dVmag**	**Date**	**N**	**Notes**
C	21 00 07.465	48 41 02.08	0.07	0.10	4.394	0.122	128.749	1.591	10.753	0.101	85.82	0.10	700	5	7
D	21 00 07.811	48 40 59.33							12.317	0.106	29.59				
C	21 00 07.465	48 41 02.21	0.09	0.06	4.172	0.108	131.604	1.485	10.860	0.072	59.83	0.07	639	5	8
D	21 00 07.780	48 40 59.44							12.212	0.079	29.03				
C	21 00 07.470	48 41 02.21	0.06	0.06	4.264	0.085	131.588	1.140	10.902	0.010	106.91	0.05	615	5	5
D	21 00 07.792	48 40 59.38							12.283	0.055	48.38				
C	21 00 07.464	48 41 02.23	0.06	0.06	4.368	0.085	131.954	1.113	10.902	0.011	102.75	0.04	620	5	6
D	21 00 07.792	48 40 59.31							12.296	0.046	48.55				
C	21 00 07.471	48 41 02.23	0.08	0.07	4.306	0.106	131.437	1.414	10.893	0.051	110.29	0.05	632	5	35
D	21 00 07.797	48 40 59.38							12.264	0.054	52.29				
C	21 00 07.467	48 41 02.19	0.073	0.072	4.300	0.102	131.055	1.363	10.862	0.060			641	25	
D	21 00 07.794	48 40 59.37							12.274	0.071					

Notes to Table 5.

1. iT24 stack 5x3s. SNR B < 20.
2. i24 stack 5x3s_2. SNR B < 20.
3. iT18 stack 5x3s. SNR B < 20.
4. A too bright for reliable photometry. SNR B < 20.
5. iT24 stack 5x3s.
6. iT24 stack 5x3s_2.
7. iT21 stack 5x3s.
8. iT18 stack 5x3s.
9. A too bright for reliable photometry.
10. iT18 stack 5x3s. SNR D < 20.
11. iT24 stack 5x3s. A and B too bright for reliable photometry.
12. iT24 stack 5x3s_2. A and B too bright for reliable photometry.
13. iT21 stack 5x3s. A and B too bright fro reliable photometry.
14. iT18 stack 5x3s. A and B too bright fro reliable photometry.
15. A and B too bright for reliable photometry.
16. iT24 stack 5x3s. SNR G < 20.
17. IT24 stack 5x3s_2. SNR G < 20.
18. iT21 stack 5x3s. SNR G < 10.
19. iT18 stack 5x3s. SNR G < 20.
20. A too bright for reliable photometry. SNR G < 20.
21. iT24 stack 5x3s. Elongation indicates this being a double itself.
22. iT24 stack 5x3s_2. No elongation.
23. iT21 stack 5 x 3s. SNR H < 20.
24. iT18 stack 5x3s. SNR H < 20.
25. A too bright for reliable photometry. SNR H < 20. Indication of H being a double itself only in one image, thus not confirmed.
26. iT21 stack 5x3s. SNR J < 20.
27. iT18 stack 5x3s. SNR J < 20.
28. A too bright for reliable photometry. SNR J < 20.
29. iT24 stack 5x3s. SNR K < 5.
30. it24 stack 5x3s_2. SNR K < 10.
31. iT18 stack 5x3s. SNR K < 5.
32. A too bright for reliable photometry. SNR K < 5.
33. E too bright for reliable photometry.
34. A too bright for reliable photoemetry and photometry 1)
35. iT18 stack 5x3s. SNR E < 20.
36. iT21 stack 5x3s. SNR E < 20.
37. iT24 stack 5x3s_3
38. 38. Components too close, no resolution. A too bright for reliable photometry.

1) The very bright primary of STT433 poses in our setup besides the usual photometry issue with bright stars also an astrometry challenge as the star disk gets huge and the large central area is populated with ADU values per pixel near the saturation limit seasoned with random effects up and down making the centroid calculation quite difficult. This leads to the curious effect that 2 image stacks of very good quality with a rather small average plate solving error from the same telescope deliver a position for A different by ~0.3" but at the same time a nearly identical position for the other components. Another side effect of the bright STT433 primary are heavy sparks also disturbing measurements of components

The difficulty of getting precise positions for very bright stars is also demonstrated by the results in the AAVSO **Bright Star Monitor** (BSM) **Epoch Photometry Database** (EPD) v3.0 (released October 22, 2015) with an average scatter of ~0.3" around the current URAT1 position of STT433A. That astrometry for bright stars is somewhat difficult is also demonstrated by the fact that special efforts were taken in the URAT1 survey to access stars as bright as 3rd magnitude by taking short exposures with an objective grating (Zacharias 2015)

1520	2113	3142	4360	6049	8325	9550	9987	7579	5118	3938	3145	2376	1901
1521	2749	4348	7294	11415	16077	18253	18316	14012	9338	6959	4952	3506	2768
1522	4074	6878	13167	22885	37314	49338	43815	28424	19400	12719	8686	6067	4179
1523	6134	11289	21284	46864	63725	63844	63457	60218	50559	26487	15731	9591	5834
1524	8077	16418	34256	63414	63693	63857	63729	63639	62961	49441	25904	13738	7678
1525	9169	18825	43876	63419	63801	63705	63837	63797	63734	62690	36662	16030	8939
1526	10189	22163	47588	63784	63733	63955	63672	63760	63685	62037	34478	17320	10011
1527	10381	22456	48845	63597	63591	63806	63732	63524	63724	57523	26349	14973	9073
1528	8801	18187	38933	63633	63761	63609	63762	63803	61003	36395	17236	10435	6588
1529	6730	12385	25822	48986	60096	61419	58019	50035	39680	20357	11057	6833	4425
1530	4593	7768	13368	21193	28335	31465	30523	23385	17347	11827	7086	4844	3179
1531	2866	4176	6424	9546	12785	15509	14679	11398	8195	6884	4686	3404	2439

Figure 3. STT433 ADU Readings iT24 showing the scatter in the center of the star disk

Table 6.: 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
BU 449 B	12.70	-	-	-	**12.625**	Not seen.
STT 447 C	12.20	-	-	11.231	**11.183**	Three observations pointing to C being a magnitude brighter than the WDS value.
BU 449 D	13.00	-	-	12.696	**13.121**	Glimpsed with averted vision, hinting D may be slightly brighter than the WDS value.
STT 447 E	8.48	8.373	9.015	8.782	**8.412**	No observations recorded.
ABH 148 G	14.80	14.20	-	14.192	**14.618**	No observations recorded.
ABH 148 H	13.79	13.670	-	13.442	**13.864**	Not seen.
ABH 148 I	11.65	11.595	12.063	12.034	**12.044**	One observation indicating the magnitude of I is close to the WDS value based on comparison star.
ABH 148 J	13.88	13.570	13.840	13.693	**13.988**	Not seen.
ABH 148 K	11.65	-	-	14.614	**15.593**	Not seen.
FOX 262 F	11.56	11.120	11.559	11.285	**11.596**	One observation which concluded K may cause F to appear brighter than it is.
STT 433 B	10.00	-	-	-	**10.781**	One observation indicating B was close to the WDS value, two observations suggesting B is half a magnitude fainter.
STT 433 C	9.95	10.847	9.952	-	**10.605**	One observation concluded C is reasonably close to the WDS value, one suggested it's half a magnitude fainter.
SLE 382 D	12.00	12.950	-	12.937	**13.098**	One observation that concluded D is close to 13th magnitude based on difficulty.
BU 9011 E	10.00	-	-	13.379	**13.712**	One observation which concluded E is 13th magnitude or fainter because it wasn't visible.
BU 1210 B	12.20	-	-	-	-	Not seen.
STT 425 C	10.80	-	10.801	10.577	**10.862**	Two observations suggesting the WDS magnitude was about right, one suggesting C is half a magnitude brighter than WDS mag.
STT 425 E	10.61	10.515	10.516	10.113	**10.847**	One observation which concluded E is the same magnitude as C.
STT 425 D	10.90	-	-	12.206	**12.274**	One observation which found D is about half a magnitude fainter than C.

STT Doubles with Large ΔM – Part VI: Cygnus Multiples

Table 7. Astrometry Results Compared to WDS

	WDS Coordinates	WDS Sep	WDS PA	Astrometry Coordinates	Astrometry Sep	Astrometry PA
BU 449 AB	21:39:28.710 +41:43:36.00	6.2	14	21 39 28.726 +41 43 36.04	6.030	13.894
STT 447 AC	21:39:28.710 +41:43:36.00	13.7	176	21 39 28.727 +41 43 35.99	14.055	176.438
BU 449 AD	21:39:28.710 +41:43:36.00	18.7	248	21 39 28.727 +41 43 35.99	18.949	247.945
STT 447 AE	21:39:28.710 +41:43:36.00	28.6	45	21 39 28.727 +41 43 35.99	29.011	44.450
ABH 148 AG	21:39:28.710 +41:43:36.00	33.8	337	21 39 28.727 +41 43 35.99	33.757	336.523
ABH 148 AH	21:39:28.710 +41:43:36.00	74.2	263	21 39 28.727 +41 43 36.00	74.403	262.563
ABH 148 AI	21:39:28.710 +41:43:36.00	92.7	271	21 39 28.727 +41 43 35.99	92.895	271.257
ABH 148 AJ	21:39:28.710 +41:43:36.00	71.3	94	21 39 28.727 +41 43 35.99	71.151	94.506
ABH 148 AK	21:39:28.710 +41:43:36.00	75.0	49	21 39 28.726 +41 43 36.04	74.737	48.595
FOX 262 EF	21:39:30.520 +41:43:56.50	42.0	46	21 39 30.541 +41 43 56.70	41.688	46.117
STT 433 AB	21:17:55.070 +34:53:48.80	14.2	222	21 17 55.085 +34 53 48.93	15.177 1)	219.295 1)
STT 433 AC	21:17:55.070 +34:53:48.80	21.2	181	21 17 55.085 +34 53 48.93	22.074 1)	183.627 1)
SLE 382 AD	21:17:55.070 +34:53:48.80	57.0	308	21 17 55.085 +34 53 48.93	57.095 1)	307.094 1)
BU 9011 AE	21:17:55.070 +34:53:48.80	34.2	67	21 17 55.085 +34 53 48.93	34.410 1)	67.420 1)
BU 1210 AB	21:00:06.610 +48:40:45.90	1.4	104	21 00 06.630 +48 40 46.05	-	-
STT 433 BC	21:17:54.290 +34:53:37.10	10.1	141	21 17 54.303 +34 53 37.18	13.152	141.394
STT 425 AC	21:00:06.610 +48:40:45.90	17.9	27	21 00 06.630 +48 40 46.05	18.154	27.163
STT 425 AE	21:00:06.610 +48:40:45.90	44.9	16	21 00 06.630 +48 40 46.05	45.356	15.804
STT 425 CD	21:00:07.410 +48:41:01.71	4.5	132	21 00 07.467 +48 41 02.19	4.300	131.055

1) These results have to be taken with caution due to the astrometry issue with the bright primary. For explanation see Note 1 below Table 5.

STT Doubles with Large ΔM – Part VI: Cygnus Multiples

Table 8. Astrometry Results Compared with URAT1 Coordinates

Object	URAT1 Sep	iTelescope Sep	Err Sep	Within Error Range?	URAT1 PA	iTelescope PA	Err PA	Within Error Range?
STT 447 AC	14.047	14.055	0.094	Yes	176.401	176.438	0.382	Yes
BU 449 AD	18.907	18.949	0.094	Yes	247.878	247.945	0.283	Yes
STT 447 AE	28.976	29.011	0.094	Yes	44.490	44.450	0.185	Yes
ABH 148 AG	33.731	33.757	0.094	Yes	336.598	336.523	0.159	Yes
ABH 148 AH	74.371	74.403	0.094	Yes	262.562	262.563	0.072	Yes
ABH 148 AI	92.849	92.895	0.094	Yes	271.252	271.257	0.058	Yes
ABH 148 AJ	71.190	71.151	0.094	Yes	94.496	94.506	0.075	Yes
ABH 148 AK	74.661	74.737	0.079	Yes	48.571	48.595	0.061	Yes
FOX 262 EF	41.751	41.688	0.094	Yes	46.120	46.117	0.129	Yes
STT 433 AB	15.090	15.177	0.081	No 1)	222.080	219.295	0.304	No 1)
STT 433 AC	21.864	22.074	0.081	No 1)	183.970	183.627	0.209	No 1)
SLE 382 AD	57.273	57.095	0.081	No 1)	307.235	307.094	0.081	No 1)
BU 9011 AE	34.444	34.410	0.081	Yes	67.107	67.420	0.134	No 1)
STT 433 BC	13.140	13.152	0.081	Yes	141.373	141.394	0.351	Yes
STT 425 AC	18.069	18.154	0.102	Yes	26.884	27.163	0.323	Yes
STT 425 AE	45.382	45.356	0.102	Yes	15.704	15.804	0.129	Yes
STT 425 CD	4.318	4.300	0.102	Yes	131.433	131.055	1.363	Yes

1) "No" with only minor delta to calculated error estimation for Sep and the respective PA with the exception of PA for STT 433 AB – here we have a measurement error of ~3° far beyond any calculated error estimation. This is the consequence of a STT433A plate solving error of as little as 0.008 RA seconds while STT433B is plate solved with virtually no difference compared to URAT1. For explanation see Note 1 below Table 2.3.1. It should also be noted that there is a difference of 0.240" for the position of STT433A between UCAC4 and URAT1 and 0.291" between WDS catalog data and URAT1 most probably due to proper motion. According to URAT1 the 2013.711 J2000 position is 21:17:55.093 +34:53:48.73

(Continued from page 523)

  - iT24: 610mm CDK with 3962mm focal length. CCD: FLI-PL09000. Resolution 0.62 arcsec/pixel. V-filter. Located in Auberry, California. Elevation 1405m
  - iT11: 510mm CDK with 2280mm focal length. CCD: FLI ProLine PL11002M. Resolution 0.81 arcsec/pixel. B- and V-Filter. Located in Mayhill, New Mexico. Elevation 2225m
  - iT18: 318mm CDK with 2541mm focal length. CCD: SBIG-STXL-6303E. Resolution 0.73 arcsec/pixel. V-filter. Located in Nerpio, Spain. Elevation 1650m
  - iT21: 431mm CDK with 1940mm focal length. CCD: FLI-PL6303E. Resolution 0.96 arcsec/pixel. V-filter. Located in Mayhill, New Mexico. Elevation 2225m
- AAVSO VPhot for initial plate solving
- AAVSO APASS providing Vmags for faint reference stars (indirect via UCAC4)
- UCAC4 catalog (online via the University of Heidelberg website and Vizier and locally from USNO DVD) for counterchecks
- URAT1 catalog for high precision plate solving
- Aladin Sky Atlas v8.0 for counterchecks
- SIMBAD, VizieR for counterchecks
- 2MASS All Sky Catalog for counterchecks
- URAT1 Survey (preliminary) for counterchecks
- AstroPlanner v2.2 for object selection, session planning and for catalog based counterchecks
- MaxIm DL6 v6.08 for plate solving on base of the UCAC4 catalog
- Astrometrica v4.9.1.420 for astrometry and photometry measurements

References

Buchheim, Robert, 2008, "CCD Double-Star Measurements at Altimira Observatory in 2007", *Journal of Double Star Observations*, **4**, 27-31.

Burnham, S.W., 1874, "A Fifth Catalogue of 71 New Double Stars", *Monthly Notices of the Royal Astronomical Society*, **35**, 31-48. (ADS bibliographic codes 1874MNRAS..35...31B and 1874MNRAS..35...40).

Burnham, S.W., 1906, *A General Catalogue of Double Stars Within 120° of the North Pole, Part II*, University of Chicago Press, Chicago.

Cullen, R.T., 1937, *Observations Made at the Royal Observatory, Greenwich, in the Year 1935*, London, (ADS bibliographic code 1937GOAM…11B…1J).

Fox, Philip, 1915, *Annals of The Dearborn Observatory of Northwestern University*, Vol 1, p. 199.

Greaney, Michael, 2012, "Some Useful Formulae" in R.W. Argyle, *Observing and Measuring Visual Double Stars*, 2nd Edition, Springer, New York.

Herschel, William, 1785, *Catalogue of Double Stars, Philosophical Transactions*, Vol. 75, pp. 40-127.

Hussey, W.J., 1901, *Micrometrical Observations of the Double Stars Discovered at Pulkowa Made with the Thirty-Six-Inch and Twelve-Inch Refractors of Lick Observatory*, pp. 14-16, A.J. Johnston, Sacramento.

Knapp, Wilfried; Nanson, John; Smith, Steven, 2015, "STT Doubles with Large Delta_M – Part I: Gem and Part II Leo and UMa", *Journal of Double Star Observations*, **11**, 184-195.

Knapp, Wilfried; Nanson, John; Smith, Steven, "2016, STT Doubles with Large Delta_M – Part II: Leo and UMa", *Journal of Double Star Observations*, **12**, 111-127.

Knapp, Wilfried; Nanson, John, 2016, "STT Doubles with Large Delta_M – Part III: Vir, Ser, CrB, Com and Boo", *Journal of Double Star Observations*, **12**, 128-142.

Knapp, Wilfried; Nanson, John, 2016, "STT Doubles with Large Delta_M – Part IV: Oph and Her", *Journal of Double Star Observations*, **12**, 361-373.

Knapp, Wilfried; Nanson, John, 2016, "STT Doubles with Large Delta_M – Part V: Aql, Del, Cyg and Aqr, Journal of Double Star Observing", **12**, 474-487.

Zacharias, Norbert, 2015, "Bright Star Astrometry with URAT", proceedings of invited talk at 2014 ADeLA meeting in Santiago, Chile, accepted by *Revista Mexicana de Astronomia y Astrofisica*.