

# *Journal of Double Star Observations*

VOLUME 12 NUMBER 6

October 1, 2016

## *Inside this issue:*

<b>Measurements of Some SKF Objects</b> Wilfried R.A. Knapp	507
<b>Double Star Measures Using the Video Drift Method - VII</b> Richard L. Nugent, Ernest W. Iverson	511
<b>STT Doubles with Large <math>\Delta M</math> – Part VI: Cygnus Multiples</b> Wilfried R. A. Knapp and John Nanson	519
<b>User's Guide to WdsPick</b> J. Sérot	535
<b>Measurements of Wide Tycho Double Stars in Orion</b> Wilfried R.A. Knapp and Mark McPhee	541
<b>Measurements of some Tycho Double Stars – Follow Up Canis Minor and Columba</b> Ross Gould and R.A. Knapp	547
<b>A New Double Star Observed During Lunar Occultation: TYC 6312-00761-1</b> Dave Gault and Dave Herald	556
<b>CCD Astrometric Measurements of WDS 08167+4053 Using the iTelescope Network</b> Bill Riley, Dewei Li, Junyao Li, Aren Dennis, Grady Boyce, and Pat Boyce	558
<b>Observations of Omicron 1 Cygni (STFA 50AD)</b> Jeff Bidler, Joshua Hagee, Paul McGuire, Rosa McGuire, Leslie Montes, Nicole Richardson, Arturo Rodriguez, and Mark Brewer	563
<b>CCD Measurements of the Double Star STF 1744AB</b> Mark Brewer, Gabriel Cacace, Stacey Elderbaum, Eryn Hernandez, Celine Shay, Mark Silva	567
<b>Student Measurements of the Double Star Eta Cassiopeiae</b> Mark Brewer, Gabriel Cacace, Vivian Do, Nicholas Griffith, Alexandria Malan, Hanna Paredes, Brian Peticolas, and Kathryn Stasiak	570
<b>Appendix to Mind the Gap – Jonckheere Double Stars Not Listed in the WDS</b> John Nanson	573
<b>CCD Measurements of Double Stars for 2015</b> Marcin Biskupski and Małgorzata Malinowska	577
<b>Near IR Measures II, 9-12 hr and Reference Stars</b> George Gatewood and Carolyn Gatewood	580
<b>Double Star Measurements of Beta Scorpii</b> Sean Gillette, Benjamin Funk, Ruth Schlosser, Alana Brown, Mallikai Cruz, Jeff McCarthy, Breana Rhoades, and Bill Spreng	586
<b>Measurements of Some VizieR I/330 Objects</b> Wilfried R.A. Knapp	589

# Measurements of Some SKF Objects

Wilfried R.A. Knapp

Vienna, Austria

[wilfried.knapp@gmail.com](mailto:wilfried.knapp@gmail.com)

**Abstract:** Data Mining is a contemporary form of double star detection. As all existing star catalogs are to some degree in error the question arises how good the data quality of such objects might be. For evaluation I measured a random sample (selected by altitude suitable for imaging) of SKF objects. With few exceptions the measurement results were rather close to the current WDS catalog data.

## Report

Brian Skiff (astronomer at the Lowell Observatory, see <https://lowell.edu/staff-member/brian-a-skiff/>) has over 2,500 SKF objects listed in the WDS catalog, one of the main contemporary contributors to this catalog. His activity as a double star discoverer is based mainly on data mining (see his reports in the Double Star Section Circulars of the Webb Deep Sky Society: <http://www.webbdeepsky.com/double-stars/double-star-section-circulars>) usually applying the current rule that only pairs with common proper motion are accepted for new entries in the WDS catalog. This might be a good approach to avoid excessive bloating with optical pairs easily to be found by data mining. Yet the future applicability of this concept is certainly questionable when the number of CPM pairs will explode with the new GAIA catalog and if it is such a good idea to have objects like SKF1060 (2.1" +20.1/21.9mag) or SKF289 (343.3" +10.11/13.87mag) in a double star catalog is

also rather unclear to me (see Brian Skiff's explanations below). Also the question arises how good results gained by data mining might be, considering the extent of faulty WDS data based on errors in other catalogs. To evaluate this latter question, I selected a few SKF objects in the Antlia and Hydra constellations rather high in the southern skies at the time of this research with separation and magnitudes suitable for resolution with remote telescope iT27 (see specifications in the acknowledgements).

The current (i.e., beginning of 2016) WDS catalog data for these objects is listed in Table 1.

The measurement results are given in Table 2. The RA/Dec coordinates resulting from plate solving with UCAC4 reference stars in the 10.5 to 14.5 mag range were used to calculate separation and position angle using the formula provided by R. Buchheim (2008).

$$Err\_Sep = \sqrt{dRA^2 + dSep^2}$$

Table 1: WDS Catalog Values per Start of 2015.6 for the Selected SKF Objects Intended for Measurement

WDS ID	Name		RA	Dec	Sep	M1	M2	PA	Con
10317-3840	SKF419	AB	10:31:40.690	-38:40:29.41	7.7	10.70	10.70	2	Ant
10278-3424	SKF1893	AB	10:27:47.780	-34:23:58.10	33.2	7.50	12.80	80	Ant
09499-3407	SKF792	AB	09:49:56.449	-34:06:57.00	13.4	10.94	11.00	339	Ant
10119-3809	SKF1890	AB	10:11:56.539	-38:08:34.90	27.8	10.14	10.71	84	Ant
09316-3402	SKF1886	AB	09:31:34.431	-34:01:56.70	121.7	8.90	11.80	235	Ant
12341-3045	SKF1919	AB	12:34:07.879	-30:45:23.30	11.0	9.70	13.80	103	Hya
12087-2804	SKF1914	AB	12:08:40.742	-28:04:18.50	18.8	9.01	10.90	266	Hya
09083+0509	SKF1840	AB	09:08:20.290	+05:08:39.30	20.4	9.90	13.30	154	Hya
12185-3331	SKF2116	BC	12:18:29.921	-33:30:31.90	6.1	12.20	13.50	186	Hya
10478-2411	SKF1470	AB	10:47:45.200	-24:11:27.90	2.9	13.80	13.80	318	Hya
12377-2708	SKF1923	AB.C	12:37:42.229	-27:08:19.20	122.1	5.40	13.30	272	Hya
12344-2700	SKF1920	AB	12:34:23.761	-27:00:04.10	10.6	9.60	13.00	251	Hya

## Measurements of Some SKF Objects

$Err\_Sep$  is calculated as with  $dRA$  and  $dDec$  as average RA and Dec plate solving errors.  $Err\_PA$  is the error estimation for PA calculated as

$$Err\_PA = \arctan\left(\frac{Err\_Sep}{Sep}\right)$$

in degrees assuming the worst case that  $Err\_Sep$  points in the right angle to the direction of the separation, meaning perpendicular to the separation vector.  $Mag$  is the photometry result based on UCAC4 reference stars with  $Vmag$  between 10.5 and 14.5 mag.  $Err\_Mag$  is calculated as

$$Err\_Mag = \sqrt{dVmag^2 + [2.5 \log_{10}(1 + 1/SNR)]^2}$$

with  $dVmag$  as the average  $Vmag$  error over all used reference stars and  $SNR$  is the signal to noise ratio for the given star. Date is the Bessel epoch of the observation and N is the number of images used for the reported values. The Notes column provides additional information about the comparison with the current WDS and other catalog data.

I contacted Brian Skiff on several topics in this report and got the following details:

- SKF1060 is one of several hundred similar pairs Skiff found in lists of M dwarfs whose spectra appear in the Sloan Digital Sky Survey (see also Skiff 2013). The pair might be extremely faint, but it does exist. SKF289 is a large-motion pair in which Luyten had identified at least one of the components. The link was noticed by Bob Burnham and Norm Thomas while engaged in the Lowell proper-motion survey in the 1950s and 60s. It could be that very wide pairs like this one can provide some constraint on the amount of dark matter in the disc of the Galaxy. One wonders why such a pair still has any dynamical "memory" of each other since they ought to have become completely separated on a relatively short cosmic timescale
- Skiff confirmed the SKF1886 PA error. It seems, this was not a typo, but the reason for this error remains somewhat unclear. Meanwhile, the WDS catalog was updated
- Skiff found the UCAC4 PM values for SKF1919A in error by simply 'blinking' cut-outs from the POSS-I and POSS-II digital scans. This demonstrates that data mining results based on working only through one set of catalog data without any counter checks cannot be considered reliable.

## Summary

With the curious exception of PA for SKF1886 the data quality of the SKF objects is according to the sample taken quite reliable – but this might be less a result of the good data quality of the sources used but due to the dedication of the discoverer to deliver best possible researched results. Lists produced by software sifting with predefined criteria through databases without further quality checks might be far less reliable – a potential topic for additional research.

In the long term the concept of CPM pairs acceptable for WDS listing might need some modification. While all stars with common proper motion qualify for Open Cluster objects regardless of separation, it does not make sense to accept such "pairs" as doubles which would otherwise not even qualify as optical pairs because of far too large a separation. I think anything with separation large enough to eliminate any possibility of ongoing gravitational relationship, despite obvious CPM, should be considered Open Cluster. Otherwise, all members of an Open Cluster would qualify as CPM multiples. Obviously, this is something nobody would want.

## References

- Buchheim, Robert, 2008, "CCD Double-Star Measurements at Altimira Observatory in 2007", *Journal of Double Star Observations*, **4**, 28-32.
- Skiff, Brian, 2013, "Common-motion pairs and other doubles found in spectral surveys - 4. Faint M-dwarf doubles from the Sloan Digital Sky Survey", *Webb Society Double Star Circular*, **21**, 28.

## 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
- iT27: 700mm CDK with 4531mm focal length. CCD: FLI PL09000. Resolution 0.53 arcsec/pixel. V-filter. Located in Siding Spring, Australia. Elevation 1122m
- AAVSO VPhot for initial plate solving and stacking
- 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 and for high precision plate solving

(Continued on page 510)

Measurements of Some SKF Objects

Table 2. Photometry and Astrometry Results for the Selected Objects

Disc. ID	RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Note
SKF 419	A 10 31	-38 40	0.09	0.10	7.702	0.135	181.133	1.001	10.537	0.051	143.82	0.05	2016.130	4	1
	B 10 31	-38 40							11.000	0.051	114.50				
SKF1893	A 10 27	-34 23	0.09	0.10	33.047	0.135	7 9.451	0.233	7.579	0.070	258.39	0.07	2016.182	5	2
	B 10 27	-34 23							13.089	0.073	54.04				
SKF 792	A 09 49	-34 06	0.13	0.13	13.359	0.184	339.712	0.788	10.922	0.100	139.72	0.10	2016.182	4	3
	B 09 49	-34 06							11.144	0.100	122.75				
SKF1890	A 10 11	-38 08	0.11	0.11	27.766	0.156	84.067	0.321	10.202	0.080	162.90	0.08	2016.182	5	4
	B 10 11	-38 08							10.977	0.080	134.18				
SKF1886	A 09 31	-34 01	0.06	0.10	121.767	0.117	214.626	0.055	8.942	0.060	228.17	0.06	2016.182	5	5
	B 09 31	-34 03							11.843	0.061	100.60				
SKF1919	A 12 34	-30 45	0.07	0.08	10.446	0.106	103.507	0.583	9.638	0.070	167.75	0.07	2016.188	5	6
	B 08.538	26.19							13.960	0.083	23.68				
SKF1914	A 12 08	-28 04	0.08	0.17	18.741	0.188	265.685	0.574	9.004	0.060	247.14	0.06	2016.199	4	7
	B 12 08	-28 04							10.807	0.060	152.32				
SKF1840	A 09 08	05 08	0.07	0.13	20.332	0.148	153.653	0.416	9.936	0.040	229.63	0.04	2016.199	5	8
	B 20.874	21.07							13.140	0.043	63.59				
SKF2116	B 12 18	-33 30	0.06	0.12	5.854	0.134	189.097	1.313	12.527	0.063	53.82	0.06	2016.188	5	9
	C 12 18	-33 30							13.837	0.072	26.51				
SKF1470	A 10 47	-24 11	0.04	0.12	3.165	0.126	324.600	2.289	13.688	0.055	46.65	0.05	2016.199	5	10
	B 10 47	-24 11							14.126	0.058	35.28				
SKF1923	AB 12 37	-27 08	0.07	0.10	121.704	0.122	271.318	0.057	6.339	0.091	89.15	0.09	2016.199	5	11
	C 12 37	-27 08							13.249	0.093	45.11				
SKF1920	A 12 34	-27 00	0.06	0.10	10.693	0.117	250.894	0.625	9.524	0.090	213.52	0.09	2016.199	5	12
	B 12 34	-27 00							12.871	0.092	60.54				

### Measurements of Some SKF Objects

#### Table 2 Notes

1. iT27 stack 4x3s. A and B changed according to magnitude. WDS Sep and PA within calculated measurement error range but not Mags. APASS lists here surprisingly only a combined mag of +10.11 – reasonable match with the given photometry results.
2. iT27 stack 5x3s. A too bright for reliable photometry. WDS Sep and PA within error range or at least very near, but not Mag for B. APASS lists for B +12.837mag – also slightly outside the calculated photometry error range.
3. iT27 stack 4x3s. All WDS catalog values within the calculated measurement error range.
4. iT27 stack 5x3s. WDS Sep, PA and Mag A within error range, but not Mag for B. APASS lists +10.88mag for B, also slightly outside the calculated photometry error range.
5. iT27 stack 5x3s. A too bright for reliable photometry. This is curious - no star at the given position for B. Best candidate for B seems TYC7162-01249-1. Typo for PA with 235° instead of 215° assumed. Measurements then confirm the current WDS catalog data.
6. iT27 stack 5x3s. WDS PA and Mag A within error range, Mag for B at least close - Sep outside. Some PM issue assumed. Countercheck with URAT1 not possible, southern sky not covered so far. UCAC4 shows with -98.6 and 82.2 a large PM difference for A and B in RA in opposite directions---> 3).
7. iT27 stack 4x3s. All WDS values within calculated measurement error range.
8. iT27 stack 5x3s. All WDS values within (Mag B at least near) calculated measurement error range.
9. iT27 stack 5x3s. All WDS catalog values slightly outside error range. APASS shows here only one Vmag value and UCAC4 takes in error this value for both components - but UCAC4 fmags rather support the given photometry results. Sep and PA values suggest a minor PM issue to some degree confirmed by the UCAC4 values of RA PM:-0.9, Dec PM:-1.6 for B and RA PM:-13.7, Dec PM:-23.4 for C.
10. iT27 5x3s. All WDS values within or at least near calculated measurement error range with exception of Mag B.
11. iT27 stack 5x3s. WDS Sep, PA and Mag B within or at least near the calculated measurement error range. A too bright for reliable photometry.
12. iT27 stack 5x3s. All WDS values within (Mag B at least near) calculated measurement error range .

*(Continued from page 508)*

- Aladin Sky Atlas v8.0 for counterchecks
- SIMBAD, VizieR for counterchecks
- 2MASS All Sky Survey Images for counterchecks
- AstroPlanner v2.2 for object selection, session planning and for catalog based counterchecks
- Astrometrica v4.9.1.420 for astrometry and photometry measurements

Special thanks to Brian Skiff for explaining several details mentioned in this report and for making me aware of possibilities to enhance significantly the quality of my plate solving results.



# Double Star Measures Using the Video Drift Method - VII

Richard L. Nugent

International Occultation Timing Association  
[RNugent@wt.net](mailto:RNugent@wt.net)

Ernest W. Iverson

International Occultation Timing Association  
[ewiverson@consolidated.net](mailto:ewiverson@consolidated.net)

**Abstract:** Position angles and separations for 226 multiple star systems are presented using the video drift method.

## Introduction

This is paper seven in the continuing series in double star measurements using the video drift method first proposed by Nugent and Iverson 2011. A significant advantage of this method is that data collection and subsequent data analysis is almost completely automated with little human interaction. A short video clip of the multiple star system drifting across the field of view is evaluated by the freeware program *Limovie* (Miyashita, 2006) to capture 100's to 1,000's of  $(x,y)$  positions (aka "standard coordinates") for each component. Although *Limovie* was originally written to measure the change in light levels during an occultation, it also produces a table of standard  $(x,y)$  coordinates for both components along with their brightness levels for each video frame. *VidPro*, an Excel program written by co-author Nugent, reads the  $(x,y)$  coordinate data and computes the position angle, separation for each video frame. The position angles and separations are then averaged over all video frames to give a final result.

Each double star drift is self calibrating. The *VidPro* program computes a unique scale factor, an offset from the east-west direction compared to the camera's pixel array (drift angle), and standard deviations for both position angle and separation for each drift. Using the  $(x,y)$  positions of each star for each video frame across the field of view, the offset of the video camera's chip from the true east-west direction is calcu-

lated using the method of least squares to an accuracy of better than  $0.02^\circ$ .

## Methodology

Preference was given to multiple star systems where the WDS lacked measurements for a minimum of 10 - 15 years and had less than 10 measurements. This criterion applies to most of the multiple star systems measured at the epoch of their measurement. In some cases where one component of a complex system meets this requirement, all of the other components within the reach of our telescopes were also measured for completeness even though they have been well measured in the past. We routinely look at a few well measured doubles to support ongoing efforts to compare the video drift method with other measurement methods. The faintest system measured in Table 2 had primary / secondary magnitudes of +13.2 / +16.9. Thirty-five systems had WDS magnitudes in the +14.0 to +15.6 range.

For systems in which either primary and/or secondary star magnitude exceeded  $m = +12$ , co-author Iverson used a variation of the drift method employing an integrating video camera (Iverson and Nugent 2015). Co-author Nugent uses a Collins I<sup>3</sup> image intensifier with his 14-inch SCT telescope and routinely reaches  $m = +14$  to +15.

With some doubles not measured since the early 1900's, significant deviations in position angle and sep-

## Double Star Measures Using the Video Drift Method - VII

aration were sometimes observed. This is not surprising. These doubles were checked with the interactive *Aladin Sky Atlas* webpage (from the Centre de Données astronomiques de Strasbourg) to verify that the stars originally observed were identified and re-measured by us. Updated proper motions were taken into account from catalogs from the *VizieR* database to confirm the observed changes in PA and separation.

Other doubles showed a significant deviation from the WDS summary catalog value. The observational history was obtained from the U.S. Naval Observatory and both the position angle and separation were plotted against the year of observation. In most cases the data conformed to a general trend line. In a few cases the fit was very good and the least squares correlation coefficient was greater than 0.90. Graphing the data also showed which measurements were obviously in error. These were rejected and not included in Table 2. Just comparing a new measurement to the WDS summary catalog value and noting a large difference might cause an observer to incorrectly reject the new measurement when in fact it might be a very good measurement.

### Calibration

In our previous paper (Nugent and Iverson, 2014), we discussed how to make a one-time calibration to set the correct aspect ratio for the hardware configuration used for the recording of the videos. This calibration makes a slight adjustment to the video aspect ratio (width vs. height) to overcome the unavoidable skewing of the image aspect ratio caused by modern digital video recorders. With this one-time video size adjustment (done automatically using an AviSynth script when *Limovie* opens the video file), our video aspect ratios closely matched the sky in the east-west and north-south directions. To confirm this, we measured long term stable doubles with no change in PA, Sep and also used RA, DEC coordinates from the *VizieR* online star catalogs to compute the angular displacement and separation of known stars.

The telescope equipment used and scale factors are summarized in Table 1.

### Acknowledgements

This research makes use of the *Washington Double Star Catalog* maintained at the US Naval Observatory, the *Aladin Sky Atlas* Interactive webpage and the *VizieR* catalog database from the Centre de Données Astronomiques in Strasbourg, France.

### References

- Aladin Interactive Sky Atlas, Centre de Données Astronomiques de Strasbourg, <http://aladin.u-strasbg.fr/java/nph-aladin.pl>.
- Iverson, E. and Nugent, R., 2015, *Journal of Double Star Observations*, **11**, 91-97.
- Miyashita, K. 2006, *Limovie, Light Measurement Tool for Occultation Observation Using Video Recorder*, [http://www005.upp.so-net.ne.jp/k\\_miyash/occ02/limovie\\_en.html](http://www005.upp.so-net.ne.jp/k_miyash/occ02/limovie_en.html).
- Nugent, R. and Iverson, E. 2011, *Journal of Double Star Observations*, **7**, 185-194.
- VizieR catalogue data base: Centre de Données Astronomiques de Strasbourg, <http://vizier.u-strasbg.fr/viz-bin/VizieR>.

Table 1. Telescopes/cameras used in this research.

Telescope	Aperture	Focal Length	Scale Factor*	Video Camera**
Meade LX-200GPS ACF optics	14" (35 cm)	3556mm f/10	0.62"/pixel	Stella Cam 3
Meade LX-200GPS Classic	14" (35 cm)	3556mm f/10	0.6"/pixel	Watec 902H Ultimate

\*Scale factors will vary slightly due to the declination of the target.

\*\*To reach fainter doubles E. Iverson uses the Stella Cam 3 integrating camera; R. Nugent uses a Watec 902H Ultimate camera with the Collins I<sup>3</sup> image intensifier.

**Double Star Measures Using the Video Drift Method - VII**

*Table 2. Results of 226 Double Stars Using the Video Drift Method*

WDS	Designation	PA°	$\sigma$ -PA	Sep"	$\sigma$ -Sep	Date	No. of (x,y) pairs	Mag Pri	Mag Sec	Drifts	Nights
00018-1912	HJ 3232	338.1	2.6	13.9	0.61	2015.860	1581	10.44	12.90	2	1
00049-1320	GAL 295	19.7	1.1	38.8	0.69	2015.860	1496	10.65	11.74	2	1
00059-1426	HJ 3238	239.8	1.1	33.6	0.62	2015.860	1423	9.65	11.75	2	1
00066-1101	GAL 3AB,C	14.7	3.7	6.8	0.56	2015.860	1540	10.56	10.80	2	1
00069-3036	HDS 10	193.9	1.7	19.8	0.47	2015.860	1719	10.31	12.00	2	1
00110-0627	J 1432	269.9	2.6	6.6	0.43	2015.860	1479	11.10	12.70	2	1
00111-2239	HJ 3351	134.9	2.1	11.5	0.46	2015.860	1600	11.33	11.28	2	1
00120-1600	ARA 8	132.3	2.2	10.5	0.42	2015.860	1556	11.50	12.10	2	1
00136-2202	ARA1599	119.3	2.2	5.5	0.24	2015.860	2408	10.92	12.50	2	1
00144-1424	GAL 296	100.6	0.9	24.0	0.34	2015.860	1444	6.5	11.00	2	1
00146-3604	HJ 3354	334.5	2.0	16.7	0.53	2015.860	1848	10.48	11.05	2	1
00147-1245	HDO 7	5.5	0.8	6.5	0.21	2015.860	1514	8.11	11.15	2	1
00148-2859	RSS 1	320.9	0.6	55.5	0.52	2015.860	1573	10.23	10.31	2	1
00158-1159	STF 14	235.8	2.3	14.4	0.59	2015.860	1501	8.90	10.85	2	1
00175+0019	STF 23AB	215.9	0.6	10.34	0.12	2015.945	6025	7.88	10.28	8	1
00594+0047	STF 80AB	338.3	0.2	29.40	0.13	2015.945	6024	7.82	9.05	8	1
01038+0122	STF 84AB	253.3	0.5	15.97	0.14	2015.945	5882	6.11	9.52	8	1
01488-0125	STF 171AB	164.5	0.2	34.07	0.13	2015.945	6021	9.61	9.74	8	1
02245-0145	STF 265	136.0	0.5	12.21	0.12	2015.945	6066	9.14	9.57	8	1
02249-0207	STF 266	266.6	0.5	7.72	0.10	2015.945	6109	9.10	9.25	8	1
02260+2324	POU 187AB	320.1	2.1	8.7	0.39	2015.858	1529	11.10	12.80	2	1
02260+2324	UC 738AC	215.9	0.4	54.5	0.31	2015.858	1424	11.10	11.65	2	1
02425-0119	BAL 279	41.4	1.0	6.06	0.11	2015.945	6063	10.07	10.24	8	1
02579+0025	STF 332	53.8	0.5	12.06	0.10	2015.945	5727	8.94	9.10	8	1
03598+1133	STF 478AB	137.4	0.7	9.62	0.13	2015.951	6158	8.83	10.22	8	1
04065+1422	S 443AB	103.9	0.2	40.15	0.12	2015.951	5763	8.99	9.53	8	1
04065+1422	S 443AC	309.4	0.0	187.78	0.12	2015.951	3836	9.00	7.36	8	1
04459+1911	AG 311AB	112.2	0.2	33.00	0.12	2015.951	6023	8.90	9.32	8	1
04472+2027	KU 85	32.6	0.2	33.52	0.10	2015.951	6291	9.64	10.45	8	1
04486+1748	STF 598	317.0	0.7	9.15	0.11	2015.951	6347	8.10	9.96	8	1
05192+2008	STF 680	201.9	0.8	9.43	0.13	2015.951	5797	6.22	9.66	8	1
05217+1854	KU 87AB	103.9	0.2	35.94	0.12	2015.951	5988	7.85	9.98	8	1
05223+3348	STF 687AB	69.0	0.9	17.1	0.24	2016.173	1750	8.69	9.77	2	1
05223+3348	ABH 29AF	174.9	0.5	69.3	0.48	2016.173	865	8.69	13.21	1	1
05223+3348	STF 687A,CD	154.6	0.3	48.2	0.25	2016.173	1745	8.69	10.22	2	1
05281+3519	SEI 268AB	221.4	2.5	8.6	0.33	2016.173	1655	10.8	11.0	2	1
05281+3519	SEI 267AC	217.3	1.5	15.7	0.34	2016.173	1679	10.8	11.0	2	1
05281+3519	SEI 269AD	147.0	1.3	19.9	0.39	2016.173	1664	10.8	11.0	2	1
05281+3519	SEI 265AF	301.0	1.3	27.4	0.46	2016.173	1599	10.8	11.0	2	1

*Table 2 continues on next page.*

### Double Star Measures Using the Video Drift Method - VII

Table 2(continued). Results of 226 Double Stars Using the Video Drift Method

WDS	Designation	PA°	$\sigma$ -PA	Sep"	$\sigma$ -Sep	Date	(x,y) pairs	Mag Pri	Mag Sec	Drifts	Nights
05281+3519	BKO 241AG	2.2	1.1	22.9	0.53	2016.173	1703	10.8	13.1	2	1
05281+3519	BKO 241DH	100.3	2.0	11.6	0.35	2016.173	1675	11.0	13.3	2	1
05281+3520	BKO 240AB	146.0	1.7	12.8	0.31	2016.173	1752	11.9	12.8	2	1
05281+3520	BKO 240AC	65.7	1.9	17.1	0.42	2016.173	1714	11.9	12.6	2	1
05281+3520	BKO 240AD	356.2	1.3	19.7	0.41	2016.173	1756	11.9	12.5	2	1
05281+3520	BKO 240CF	125.9	3.0	9.7	0.46	2016.173	1768	12.6	13.1	2	1
05298+1825	HJ 3275AC	21.4	0.1	56.10	0.11	2015.951	6184	7.65	8.22	8	1
05364+2111	STF 740	120.9	0.3	21.64	0.12	2015.951	6287	9.01	9.93	8	1
05381-0011	S 493AE	262.8	0.0	138.31	0.12	2015.052	3793	7.96	8.67	8	1
05381-0011	STF 758AC	87.3	0.1	51.34	0.11	2015.052	5210	7.96	8.69	8	1
05381-0011	STF 758AD	79.4	0.2	41.92	0.11	2015.052	5163	7.96	8.52	8	1
05381-0011	STF 758CD	297.9	0.5	11.35	0.10	2015.052	5678	8.69	8.52	8	1
05421+2135	STF 772AB,C	242.8	0.2	30.62	0.10	2015.951	6107	8.88	9.65	8	1
05456+2141	J 1905	264.0	1.9	5.83	0.21	2015.951	1014	10.55	10.9	3	1
05526-2328	ARA1995	93.9	1.4	11.7	0.33	2016.173	2294	12.9	13.4	3	1
05529+1609	SKF2493	270.0	1.4	10.2	0.41	2016.173	1537	11.0	11.5	2	1
05530+2400	POU 802AB	316.5	2.1	11.5	0.38	2016.173	1556	10.43	13.3	2	1
05530+2400	POU 803AC	78.8	1.5	16.0	0.40	2016.173	1528	10.43	13.98	2	1
06031+1248	BRT1193AB	110.0	1.2	5.41	0.06	2015.134	10214	10.6	11.0	6	1
06031+1248	BRT1193AC	201.3	1.4	7.74	0.15	2015.134	11512	10.6	11.2	3	1
06112+2313	POU1114	165.6	3.0	12.5	0.66	2016.170	1494	11.0	14.0	2	1
06112+2315	POU1117AC	357.5	1.0	12.5	0.23	2016.170	1527	12.8	12.6	2	1
06115+2314	POU1123	184.6	1.1	7.1	0.22	2016.170	834	11.31	14.1	2	1
06170+2342	POU1189	237.3	3.3	8.1	0.46	2016.173	1621	11.6	13.6	2	1
06220+2429	POU1260	241.5	2.0	17.2	0.55	2016.170	1612	13.0	14.3	2	1
06225-2003	ARA 542	115.5	1.8	10.8	0.36	2016.170	1587	12.6	13.5	2	1
06348+0819	BRT2120	82.8	3.8	3.3	0.43	2016.170	1465	11.0	10.3	2	1
06357+2258	POU1556AB	129.6	2.9	11.7	0.53	2016.170	1027	12.4	13.8	2	1
06357+2258	POU1557AC	154.7	1.4	21.8	0.50	2016.170	998	12.4	14.4	2	1
06359+2258	POU1574AB	167.5	1.4	16.6	0.39	2016.170	1607	13.31	15.27	2	1
06361+2257	POU1579	47.9	2.3	11.6	0.43	2016.173	2400	13.2	14.2	3	1
06363+2300	POU1592	145.6	2.7	16.4	0.71	2016.170	1575	13.7	14.1	2	1
06364+2257	POU1598	35.2	3.6	11.7	0.71	2016.170	1532	13.0	14.0	2	1
06365+2252	POU1604	186.3	2.1	9.7	0.38	2016.170	1625	11.4	14.3	2	1
06367+2259	POU1613	12.8	2.3	13.7	0.51	2016.170	1606	11.41	13.8	2	1
06368+2255	POU1619AB	30.0	2.8	6.9	0.36	2016.170	1555	11.9	13.1	2	1
06368+2255	POU1620AC	62.4	2.4	9.8	0.38	2016.170	1609	11.9	14.4	2	1
06375+2259	POU1670	260.7	2.3	14.3	0.63	2016.170	1558	11.37	14.0	2	1
06381+2305	POU1710	119.5	3.1	13.1	0.72	2016.170	1500	14.1	14.5	2	1

Table 2 continues on next page.

### Double Star Measures Using the Video Drift Method - VII

*Table 2 (continued). Results of 226 Double Stars Using the Video Drift Method*

WDS	Designation	PA°	$\sigma$ -PA	Sep"	$\sigma$ -Sep	Date	(x,y) pairs	Mag Pri	Mag Sec	Drifts	Nights
06382+2305	POU1714	139.8	2.4	15.0	0.60	2016.170	1574	13.0	14.3	2	1
06540-0207	BAL 91	357.1	1.8	11.4	0.50	2016.173	1521	11.68	12.2	2	1
07079+1053	SIN 121AB	305.5	0.5	42.0	0.43	2016.173	1392	8.89	12.51	2	1
07079+1053	SIN 121AG	257.9	0.2	112.9	0.41	2016.173	1074	8.89	9.14	2	1
07131-0141	ARG 65	185.4	2.3	8.1	0.38	2016.178	1499	10.86	11.7	2	1
07138+0536	XMI 51	173.0	0.8	20.8	0.30	2016.178	1526	10.93	11.36	2	1
07139+0809	XMI 52	335.8	1.0	20.8	0.36	2016.178	1494	11.38	11.40	2	1
07140-0101	BAL 781	188.3	2.0	11.6	0.40	2016.178	1498	12.15	12.22	2	1
07141-0053	BAL 782	243.4	1.4	16.6	0.40	2016.178	1472	12.17	13.0	2	1
07144-1519	ROE 26AB	120.5	1.5	8.7	0.26	2016.178	1279	9.71	13.1	2	1
07144-1519	ROE 26AC	50.5	0.4	52.0	0.28	2016.178	1869	9.71	12.69	2	1
07156+0024	BAL1090	221.8	1.6	15.6	0.49	2016.178	1474	11.26	11.7	2	1
07255-1914	ARA 581	94.0	1.8	11.1	0.42	2016.175	1449	11.7	12.8	2	1
07258+0107	BAL1402	6.3	1.2	16.3	0.34	2016.175	1513	11.19	11.27	2	1
07258-2020	ARA 925	337.6	3.5	6.1	0.41	2016.175	1517	10.69	11.5	2	1
07258-2228	ARA1687	83.2	2.4	6.4	0.30	2016.175	1541	10.44	12.7	2	1
07260-2041	ARA 927	123.7	2.4	11.0	0.51	2016.175	1466	11.6	11.49	2	1
07260-2142	ARA1338	191.0	2.2	10.1	0.37	2016.175	1595	12.3	12.4	2	1
07261-2146	ARA1339	64.6	1.8	9.1	0.37	2016.175	1586	10.48	12.3	2	1
07261-2409	ARA2048AB,C	338.0	1.6	11.8	0.31	2016.175	1409	9.2	11.7	2	1
07264-0111	BAL 810	297.3	2.5	12.6	0.66	2016.175	1456	11.0	11.1	2	1
07266-0016	BAL 812	128.8	1.5	11.3	0.40	2016.175	1438	12.15	11.02	2	1
07266-0033	BAL 811	176.4	1.7	11.1	0.48	2016.175	1501	11.3	11.4	2	1
07268-2213	ARA1688	241.2	0.6	12.1	0.12	2016.175	1516	10.9	11.7	2	1
07269-1937	ARA 583	137.3	1.4	13.7	0.36	2016.175	1559	10.53	10.7	2	1
07270-2109	ARA 929	197.0	1.4	14.8	0.34	2016.175	1591	11.40	11.72	2	1
07270-3046	B 1544AB	205.4	2.2	6.3	0.19	2016.175	1656	9.15	10.68	2	1
07270-3046	B 1544AC	148.9	0.1	145.1	0.23	2016.175	1005	9.15	11.79	3	1
07272-0535	J 2632AB	71.9	0.5	34.0	0.32	2016.175	1352	9.29	11.98	2	1
07272-0535	J 2632BC	143.9	3.0	5.1	0.28	2016.175	1449	12.5	13.0	2	1
07273-2355	ARA2050AB	42.7	2.0	12.5	0.41	2016.175	1616	10.99	12.21	2	1
07273-2355	ARA2050AC	193.7	0.8	9.4	0.17	2016.175	1631	10.99	12.80	2	1
07273-2355	ABH 67AD	249.0	0.5	40.1	0.38	2016.175	1471	10.99	9.48	2	1
07273-2355	ABH 67AE	244.8	0.2	54.9	0.23	2016.175	1445	10.99	14.2	2	1
07273-2355	ABH 67AF	246.8	0.4	92.2	0.59	2016.175	1264	10.99	13.72	2	1
07273-2355	ABH 67AG	275.3	0.2	125.2	0.50	2016.175	1132	10.99	12.99	2	1
07273-2355	ABH 67AH	204.4	0.4	80.8	0.52	2016.175	1483	10.99	13.61	2	1
07273-2355	ABH 67AI	38.1	0.5	69.8	0.56	2016.175	1429	10.99	13.53	2	1
07273-2355	ABH 67AJ	36.2	0.5	62.0	0.52	2016.175	1454	10.99	13.56	2	1

*Table 2 continues on next page.*

### Double Star Measures Using the Video Drift Method - VII

*Table 2 (continued). Results of 226 Double Stars Using the Video Drift Method*

WDS	Designation	PA°	$\sigma$ -PA	Sep"	$\sigma$ -Sep	Date	(x,y) pairs	Mag Pri	Mag Sec	Drifts	Nights
07273-2355	ABH 67AL	48.6	1.4	31.5	0.98	2016.175	2362	10.99	14.0	3	1
07273-2355	ABH 67AM	145.7	0.7	35.9	0.41	2016.175	1534	10.99	11.33	2	1
07273-2355	ABH 67AO	139.2	0.3	74.2	0.40	2016.175	1396	10.99	9.04	2	1
07273-2355	ABH 67AP	135.7	0.3	113.6	0.49	2016.175	1290	10.99	10.87	2	1
07273-2355	ABH 67AQ	186.8	0.4	63.3	0.37	2016.175	1536	10.99	14.9	2	1
07273-2355	ABH 67AR	172.3	0.3	57.2	0.29	2016.175	1591	10.99	14.5	2	1
07273-2355	ABH 67AS	179.0	0.3	41.8	0.27	2016.175	1621	10.99	14.3	2	1
07273-2355	ABH 67AT	189.8	0.4	31.7	0.29	2016.175	1574	10.99	14.4	2	1
07273-2355	ABH 67AV	294.8	0.6	53.3	0.56	2016.175	1401	10.99	14.86	2	1
07273-2355	ARA2052PX	50.6	1.6	13.5	0.38	2016.175	1614	10.87	11.6	2	1
07453-0026	HJ 767AB	163.3	0.8	20.8	0.33	2016.173	1481	7.99	10.64	2	1
07453-0026	SIN 31AE	27.2	1.6	28.4	2.19	2016.173	677	7.99	12.3	2	1
07459-0121	BAL 488	69.4	1.7	16.5	0.51	2016.173	1444	11.1	11.1	2	1
08088-1844	ARA 394	333.9	3.1	7.2	0.42	2016.178	1564	10.6	12.1	2	1
08091-2236	ARA1722	347.6	2.9	8.8	0.56	2016.178	1531	9.86	12.4	2	1
08104-2156	ARA1432	29.4	2.9	12.0	0.56	2016.170	1603	11.63	13.5	2	1
08105-2203	ARA1433	108.5	1.4	17.8	0.44	2016.170	1559	11.47	11.9	2	1
08108-1635	XMI 80	29.4	0.9	20.7	0.31	2016.178	1515	9.60	10.88	2	1
08113-1956	ARA 635AB	71.9	1.9	15.9	0.49	2016.178	1512	12.7	13.6	2	1
08113-1956	ARA 635BC	344.3	3.4	8.9	0.55	2016.178	1595	13.6	13.6	2	1
08115+1041	HJ 777AB	348.7	0.8	10.6	0.15	2016.178	1810	9.58	11.7	3	1
08115+1041	HJ 777AC	104.4	0.2	113.0	0.50	2016.178	1021	9.58	14.02	2	1
08123+0157	BAL1839	119.8	1.4	14.0	0.39	2016.178	1496	11.4	11.5	2	1
08127+0859	OSB 6	192.6	3.9	9.5	0.68	2016.178	1491	12.59	14.13	2	1
08129+1044	BPM 436	203.3	0.3	116.7	0.47	2016.178	1367	11.40	13.48	2	1
08133-2200	ARA1435	87.0	1.3	13.8	0.40	2016.178	1575	10.4	12.0	2	1
08135-0123	HJ 85	84.6	1.1	16.7	0.31	2016.178	1458	11.27	11.61	2	1
08135-3624	HJ 4060	178.7	0.6	21.7	0.33	2016.178	1872	8.11	10.00	2	1
08137-1407	HJ 779AB	301.8	1.0	20.1	0.37	2016.178	1488	11.16	12.3	2	1
08137-1407	HJ 779AC	130.1	1.0	21.4	0.39	2016.178	1491	11.16	12.4	2	1
08137-1407	DAM 63AD	78.2	1.8	10.6	0.34	2016.178	1508	11.16	13.6	2	1
08137-1407	DAM 63AE	177.2	1.3	12.6	0.37	2016.178	1470	11.16	13.68	2	1
08306-0247	BAL 198	67.1	1.2	17.4	0.38	2016.173	1416	11.76	12.64	2	1
08312-1100	GWP1029	325.2	0.6	57.4	0.67	2016.173	1354	11.21	14.76	2	1
08317+1924	LDS 905AB	348.6	2.6	9.7	0.44	2016.170	1564	11.90	14.01	2	1
08377+1946	STF1249	40.4	0.6	25.0	0.28	2016.170	1523	11.00	10.78	2	1
08491-1440	HJ 797	138.4	1.3	16.6	0.41	2016.175	1484	10.34	13.7	2	1
08500+1155	BPM 455	294.4	0.3	69.3	0.40	2016.175	1257	9.12	12.47	2	1
08508+1143	BPM 456	338.3	0.6	88.8	0.83	2016.175	1349	13.16	14.14	2	1

*Table 2 continues on next page.*

## Double Star Measures Using the Video Drift Method - VII

Table 2 (continued). Results of 226 Double Stars Using the Video Drift Method

WDS	Designation	PA°	$\sigma$ -PA	Sep"	$\sigma$ -Sep	Date	(x,y) pairs	Mag Pri	Mag Sec	Drifts	Nights
08596+0146	BAL1855	85.9	1.2	16.6	0.39	2016.175	1424	10.03	12.92	2	1
09007+1353	HJ 112	339.0	2.7	8.3	0.46	2016.175	1266	12.	13.	2	1
09009+0644	GWP1128AB	237.8	0.4	125.3	0.80	2016.170	1055	13.66	14.19	2	1
09009+0644	CLZ 47AC	198.3	1.1	45.3	0.83	2016.170	1256	13.66	16.0	2	1
09009+1035	UC 128	352.1	1.5	11.7	0.35	2016.170	1505	11.41	14.49	2	1
09015-2742	BRT2963	206.9	2.7	7.4	0.37	2016.170	1229	12.6	12.6	2	1
09593-2631	LDS3945	128.4	0.2	164.1	0.54	2014.871	972	12.41	13.26	2	1
11151+2120	WNO 36AC	58.4	1.3	19.6	0.44	2015.375	2270	14.6	14.5	3	1
11330-3151	HJ 4449AB	134.4	0.0	74.6	0.00	2015.375	730	3.54	10.7	1	1
11480-0838	STF3074	302.0	0.6	10.85	0.11	2015.238	6028	9.60	9.71	8	1
13064+3042	CRB 93	106.9	1.5	26.0	0.66	2015.375	1645	13.80	14.42	2	1
13115+4024	BVD 228	191.2	1.4	38.4	0.66	2015.375	1926	13.18	13.72	2	1
13254-0209	BAL 550	319.8	1.3	18.0	0.42	2015.375	1453	11.56	12.0	2	1
13288+2757	LDS1391	45.2	0.3	134.3	0.57	2015.375	1211	10.24	14.2	2	1
13444+2536	BUP 152AC	149.6	0.3	94.7	0.53	2015.466	1436	10.82	13.97	2	1
13577-2525	J 1610	283.4	1.2	11.0	0.25	2015.468	2377	11.3	11.6	3	1
14189-1752	LDS 486	8.6	1.1	34.2	0.57	2015.468	1548	13.2	14.8	2	1
14308-0839	BUP 158	96.4	0.1	162.4	0.47	2015.375	849	9.58	10.85	2	1
14438+2352	AZC 88	7.8	0.7	40.4	0.43	2015.375	2183	10.03	14.41	3	1
14475-3658	SEE 211	182.1	0.7	13.8	0.18	2015.468	1858	8.41	13.7	2	1
15125-3555	RSS 367AB	103.9	1.3	6.5	0.15	2015.466	1830	8.42	13.0	2	1
15160-0454	STF3091AB,E	46.4	0.4	41.3	0.30	2015.466	1386	7.30	12.0	2	1
15169-0817	STF1925AB	17.6	2.1	5.7	0.18	2015.466	1513	8.14	9.85	2	1
15169-0817	STF1925AC	291.5	0.4	62.3	0.61	2014.874	617	8.14	14.42	1	1
15407+2339	AZC 93	170.1	0.6	41.7	0.40	2015.375	1505	14.25	15.6	2	1
15434-1037	J 2663	52.9	2.4	6.9	0.32	2015.466	1513	12.4	12.3	2	1
16134-2758	AOT 64	145.6	1.1	13.6	0.23	2015.468	1679	10.3	11.23	2	1
17129+3451	CRB 119	34.4	0.5	25.5	0.14	2015.375	1054	13.2	16.9	3	1
18295+2959	KU 118	322.9	0.1	50.20	0.09	2015.521	7525	9.16	9.30	9	1
18554-0552	J 2241AB	214.7	0.3	29.53	0.15	2015.696	5897	10.52	11.82	8	1
18554-0552	J 2241BC	258.1	1.3	5.30	0.17	2015.696	8232	11.82	13.8	6	1
19371+0819	STF2544AC	238.7	0.4	13.64	0.11	2015.641	5558	8.62	9.87	8	1
19395+1012	HJ 893	190.0	0.6	7.71	0.09	2015.641	5970	9.48	10.09	8	1
19471+2701	OSB 8AB	9.9	0.5	13.96	0.10	2015.521	7814	10.76	11.83	9	1
19471+2701	TOB 160AC	212.1	0.3	29.96	0.13	2015.521	7505	10.76	12.32	9	1
19534-0600	STF2591	106.2	0.2	29.33	0.11	2015.696	5793	8.74	9.23	8	1
19579+2715	AC 16AC	135.5	0.1	92.89	0.10	2015.521	6590	7.81	7.97	9	1
20001+1111	HJ 1458	312.4	0.4	16.17	0.11	2015.668	6194	9.27	9.43	8	1
20029+1056	AG 397	113.8	0.2	29.13	0.12	2015.668	5968	8.86	9.68	8	1

Table 2 concludes on next page.

### Double Star Measures Using the Video Drift Method - VII

Table 2 (conclusion). Results of 226 Double Stars Using the Video Drift Method

WDS	Designation	PA°	$\sigma$ -PA	Sep"	$\sigma$ -Sep	Date	(x,y) pairs	Mag Pri	Mag Sec	Drifts	Nights
20054+2716	HJ 1473	138.0	0.5	10.48	0.08	2015.521	7707	10.47	10.67	9	1
20070+1035	HJ 904	308.2	0.2	30.00	0.12	2015.668	5975	8.49	10.90	8	1
20072+1037	HJ 905	176.9	0.5	12.08	0.11	2015.668	3647	8.85	10.82	8	1
20116-0609	BU 833AB	63.2	0.1	127.04	0.13	2015.696	4388	8.35	9.21	8	1
20116-0609	BU 833AD	351.6	0.3	43.57	0.24	2015.696	7527	8.35	13.89	2	1
20144-0603	STF2646AB	39.7	0.4	17.76	0.12	2015.696	5960	7.49	9.28	8	1
20144-0603	STF2646BC	105.5	0.4	26.92	0.22	2015.696	8018	9.28	12.96	2	1
20178+0612	AG 251AB	185.5	0.8	7.12	0.11	2015.641	5918	8.61	10.0	8	1
20210+1028	J 838	118.7	1.9	6.74	0.21	2015.668	9119	11.52	12.0	2	1
20392+1059	SCJ 27AB	262.3	1.0	6.14	0.12	2015.668	6319	8.67	10.03	8	1
20418-0430	HJ 921	219.7	0.6	9.32	0.11	2015.696	6084	9.47	9.71	8	1
20426+1244	STF2718AB	87.1	0.3	8.46	0.07	2015.773	12364	8.28	8.39	16	2
20499+1255	HJ 1577	245.5	0.5	9.28	0.08	2015.773	12278	8.91	9.4	16	2
20537+0336	BAL2548	257.7	0.9	7.49	0.11	2015.641	6180	9.90	10.85	8	1
20541+1306	STF2734	227.3	0.3	24.07	0.11	2015.668	6136	9.39	9.82	8	1
20591+0418	STF2737AB,C	68.7	0.6	10.39	0.11	2015.641	5998	5.30	7.05	8	1
21105+2452	POU5216	191.1	4.2	5.7	0.47	2015.767	1644	12.9	14.3	2	1
21108+2452	POU5219AB	144.5	2.4	8.0	0.33	2015.767	1680	12.0	12.9	2	1
21140+1106	AG 415AB	23.8	0.3	15.79	0.08	2015.668	12546	10.09	10.62	16	2
21546-0318	STF2838AB	182.5	0.4	15.98	0.11	2015.696	6073	6.29	9.52	8	1
21546-0318	TOK 349AC	102.1	0.1	143.80	0.35	2015.696	6252	6.28	15.16	2	1
22007-0448	SCA 113	279.2	0.3	16.22	0.11	2015.696	6030	10.71	10.88	8	1
22141-2308	FOX 45AC	86.1	0.8	28.5	0.33	2015.767	1526	10.57	11.67	2	1
22185-1751	ARA 507	196.7	3.0	5.7	0.32	2015.767	1592	11.8	12.0	2	1
22241-3944	HJ 5330	274.7	2.9	5.1	0.40	2015.767	1940	10.60	10.94	2	1
22306-1307	BRT2793	292.7	5.1	5.0	0.59	2015.767	1549	11.5	11.6	2	1
22379+0554	STF2925	3.9	0.9	7.04	0.11	2015.773	6061	9.66	10.35	8	1
22426-2057	HJ 3135	352.8	0.7	35.5	0.40	2015.767	1563	8.8	11.6	2	1
22469-0707	BRT 521	29.7	3.1	4.3	0.35	2015.767	1523	12.0	12.0	2	1
23243+0343	STF3009AB	228.4	0.9	7.26	0.13	2015.773	5815	6.87	8.76	8	1
23397+0331	BAL2069	287.2	0.8	7.68	0.11	2015.773	6394	9.95	11.22	10	1

**Table 2 Notes:**

All magnitudes taken from the WDS catalog. All position angle/separation measurements are for the Equator and Equinox of date.

Column titled "**No. of (x,y) pairs**" is the total combined no. of (x,y) pairs (video frames) from all drift runs. All video frames were used, none were discarded.

The column "**drifts**" is the number of separate drifts made. "**Nights**" is the number of nights drift runs were made for that system.

# STT Doubles with Large $\Delta M$ – Part VI: Cygnus Multiples

Wilfried R.A. Knapp

Vienna, Austria

[wilfried.knapp@gmail.com](mailto:wilfried.knapp@gmail.com)

John Nanson

Star Splitters Double Star Blog

Manzanita, Oregon

[jnanson@nehalem.tel.net](mailto:jnanson@nehalem.tel.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-

**STT Doubles with Large  $\Delta M$  – Part VI: Cygnus Multiples**

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

Name		ID	RA	Dec	Sep	PA	M1	M2	$\Delta M$
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

STT Doubles with Large  $\Delta M$  – Part VI: Cygnus Multiples

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  $28.1^\circ$ ,  $29.2^\circ$ , and  $28.4^\circ$ , which average out to the  $28.6^\circ$  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  $45.2^\circ$  and  $46.8^\circ$  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  $210^\circ$  and 21". Otto Struve added the first specific measures in 1849, which were  $219.4^\circ$  and 14.91". John Herschel was also the first to look at the AC components, again in 1827, and again estimated the measures ( $180^\circ$  and 30"), followed by Otto Struve with actual measures in 1849 ( $177.6^\circ$  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  $309^\circ : 1'$ " (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. = $21^h 13^m 22^s$		Decl. = $+34^\circ 25'$	
A and B	P = $140^\circ \pm$	D = 1"	A = $8\frac{1}{2}$ m.
A and C	$270^\circ \pm$	5"	B = 10 m.

This fine triple is in the field with  $\nu$  Cygni (O $\Sigma$  43)  $24'$  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.  $\nu$  Cygni has a third companion D in the direction of  $60^\circ$ , at a little less than 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

STT Doubles with Large  $\Delta M$  – Part VI: Cygnus Multiples

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 1/2 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.

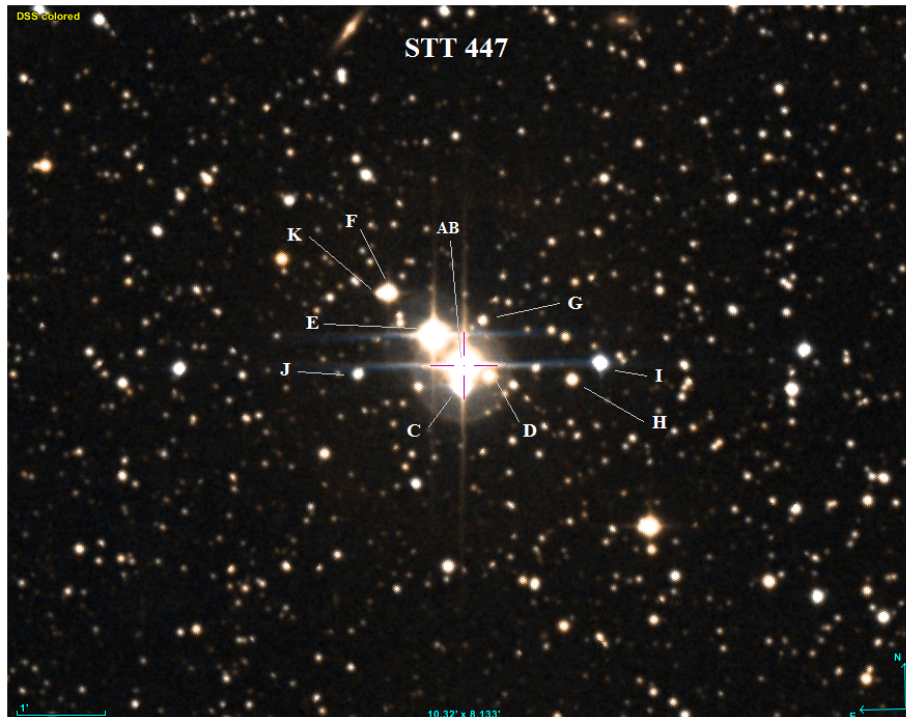


Figure 2. Aladin image of STT 447 with all components labeled.

## STT Doubles with Large $\Delta M$ – Part VI: Cygnus Multiples

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<sup>th</sup> 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  $\text{SQRT}(dRA^2 + dSep^2)$  with dRA and dDec as average RA and Dec plate solving errors. Err\_PA is the error estimation for PA calculated as  $\arctan(\text{Err\_Sep}/\text{Sep})$  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  $(dVmag^2 + (2.5 * \text{Log}_{10}(1 + 1/\text{SNR}))^2)$  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. *i*T 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	<b>21 39 28.726</b>	<b>41 43 36.04</b>	<b>0.061</b>	<b>0.051</b>	<b>6.030</b>	<b>0.079</b>	<b>13.894</b>	<b>0.750</b>	<b>7.487</b>	<b>0.068</b>			<b>630</b>	<b>15</b>	<b>4</b>
B	<b>21 39 28.855</b>	<b>41 43 41.89</b>							<b>12.625</b>	<b>0.095</b>					
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	<b>21 39 28.727</b>	<b>41 43 35.99</b>	<b>0.066</b>	<b>0.067</b>	<b>14.055</b>	<b>0.094</b>	<b>176.438</b>	<b>0.382</b>	<b>7.438</b>	<b>0.074</b>			<b>648</b>	<b>20</b>	<b>9</b>
C	<b>21 39 28.805</b>	<b>41 43 21.96</b>							<b>11.183</b>	<b>0.075</b>					
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	<b>21 39 28.727</b>	<b>41 43 35.99</b>	<b>0.066</b>	<b>0.067</b>	<b>18.949</b>	<b>0.094</b>	<b>247.945</b>	<b>0.283</b>	<b>7.438</b>	<b>0.074</b>			<b>648</b>	<b>20</b>	<b>9</b>
D	<b>21 39 27.158</b>	<b>41 43 28.87</b>							<b>13.121</b>	<b>0.084</b>					

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. ...

STT	RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
STT 447	A	21 39 28.727	41 43 36.03	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	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	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	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	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	A	21 39 28.727	41 43 36.03	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	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	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	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	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	A	21 39 28.727	41 43 36.03	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	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	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	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	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.

STT Doubles with Large ΔM – Part VI: Cygnus Multiples

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	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
	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
	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
	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
	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				
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				
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				
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				
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				
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				
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				
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	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	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	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					

STT Doubles with Large  $\Delta M$  – Part VI: Cygnus Multiples

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

STT Doubles with Large  $\Delta M$  – Part VI: Cygnus Multiples

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	-	-	-	<b>12.625</b>	Not seen.
STT 447 C	12.20	-	-	11.231	<b>11.183</b>	Three observations pointing to C being a magnitude brighter than the WDS value.
BU 449 D	13.00	-	-	12.696	<b>13.121</b>	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	<b>8.412</b>	No observations recorded.
ABH 148 G	14.80	14.20	-	14.192	<b>14.618</b>	No observations recorded.
ABH 148 H	13.79	13.670	-	13.442	<b>13.864</b>	Not seen.
ABH 148 I	11.65	11.595	12.063	12.034	<b>12.044</b>	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	<b>13.988</b>	Not seen.
ABH 148 K	11.65	-	-	14.614	<b>15.593</b>	Not seen.
FOX 262 F	11.56	11.120	11.559	11.285	<b>11.596</b>	One observation which concluded K may cause F to appear brighter than it is.
STT 433 B	10.00	-	-	-	<b>10.781</b>	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	-	<b>10.605</b>	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	<b>13.098</b>	One observation that concluded D is close to 13 <sup>th</sup> magnitude based on difficulty.
BU 9011 E	10.00	-	-	13.379	<b>13.712</b>	One observation which concluded E is 13 <sup>th</sup> magnitude or fainter because it wasn't visible.
BU 1210 B	12.20	-	-	-	-	Not seen.
STT 425 C	10.80	-	10.801	10.577	<b>10.862</b>	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	<b>10.847</b>	One observation which concluded E is the same magnitude as C.
STT 425 D	10.90	-	-	12.206	<b>12.274</b>	One observation which found D is about half a magnitude fainter than C.

STT Doubles with Large  $\Delta M$  – 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  $\Delta M$  – 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  $\sim 3^\circ$  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

STT Doubles with Large  $\Delta M$  – Part VI: Cygnus Multiples

(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*.

# User's Guide to WdsPick

J. Sérot

[jocelyn.serot@free.fr](mailto:jocelyn.serot@free.fr)

**Abstract:** WdsPick is a program developed to help the astronomer making measurements of double stars. WdsPick offers two complementary functions. First, a filter-based mechanism for building lists of target stars from the Washington Double Star Catalog [1] and navigating through these lists. Second, a connection to the well-known SkyChart [2] application for automatically visualizing star positions and pointing telescopes.

## Introduction

The behavior of the program is illustrated in Figure 1, showing both the WdsPick and SkyChart applications side by side (left and right respectively).

Here WdsPick is navigating through a list of 98 target stars. The current selection is BU 1216, whose main elements are shown (including ephemerides computed from the Sixth Catalog of Orbits of Visual Binary Stars [2]). A connection has been established with

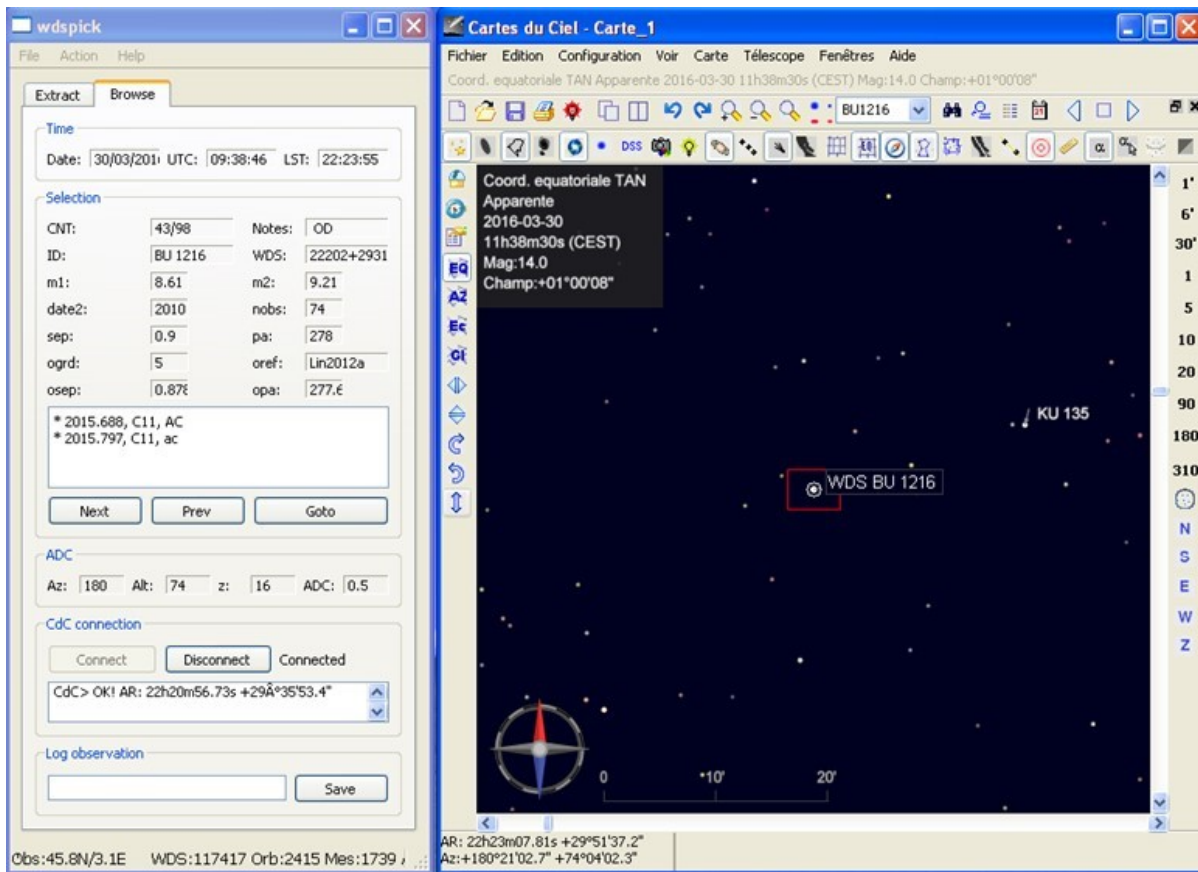


Figure 1. WdsPick in action, connected to the SkyChart application.

## User's Guide to WdsPick

the SkyChart application and the latter has been instructed to point to the corresponding position. If the SkyChart application is actually controlling a telescope (by means of an ASCOM interface, for example), initiating a physical GOTO would then automatically bring the target star in the FOV (or the camera).

### Starting WdsPick

When started, the application shows the window as illustrated in Figure 2.

The three main components of this window are

- a **menu bar** with three menus (File, Action and Help) at the top
- two *tabs* named Extract and Browse respectively (with the former initially selected)
- a **status bar** showing some informations at the bottom

The Help menu gives access to the About action which prints some information on the program.

The Action menu has only one item, Extract. Invoking this action is equivalent to hitting the **Extract** button located at the bottom of the Extract tab, or typing "Ctl-E".

The File menu has three items for loading or saving so-called *specification files* (see below) or quitting the application respectively.

The information shown in the **status bar** are, from left to right,

- the coordinates of the observatory (longitude and latitude),
- the number of entries read in the WDS and the ORB files,
- the number of entries read in MES file (see below),
- the number of entries read in the ADC file (see below).

Initially, the application shows the Extract tab, whose function is to specify the criteria used for building the target list.

### Building a Target List

This is achieved by specifying a set of filters in the Extract tab and clicking on the **Extract** button.

Available filters include

- the equatorial coordinates (*RA* and *Declination*),
- the magnitudes of the primary and secondary components (*m1* and *m2*),
- the difference in magnitudes between the two components (*dm*),
- the separation between components (*sep*, in arc seconds),



Figure 2. WdsPick main window.

- the year of the last observation, as reported in the WDS (*date2*),
- the total number of observations, as reported in the WDS (*nobs*),
- the discoverer code of the star (*disc*),
- the notes, as recorded in the WDS (*notes*).

For *RA*, *Dec*, *m1*, *m2*, *dm* and *sep*, a minimal value and/or a maximal value can be specified. Note that the specified value is included in the selection, except for the upper bound of *RA*. For the *disc* and *notes* criteria, the specified value simply has to occur in the corresponding WDS field. For example, for restricting targets to stars discovered by W. Struve, select the *Disc* criterium and enter "STF" in the corresponding text field. The filter set shown in Figure 3, for example,

(Continued on page 537)

## User's Guide to WdsPick

will select stars

- located between 6h and 7h of RA and 0 and 60° of declination,
- with a primary (resp. secondary) component brighter than or equal to magnitude 10 (resp. 12),
- with a separation between 0.5" and 1",
- with no observation reported since 2010,
- and having an orbit listed in the 6th Orbit Catalog.

The matching entries are extracted from the WDS file (this can take a few seconds) and the application automatically switches to the Browse tab.

The current set of filters can be saved in (resp. loaded from) a file by invoking Save (resp. Open) from the File menu (keyboard shortcuts : Ctl-S and Ctl-O resp.).

Note that it is possible to go back to the Extract tab at any any time to change the filter set and build a new target list.

### Browsing the target list

Figure 4 shows the Browse tab obtained with the aforementioned criteria. The different items are grouped in five categories: Time, Selection, ADC, CdcConnection, and Log.

#### Time group

Here WdsPick displays the current date, UTC time, and local sidereal time (LST). The latter is correct only if the local coordinates of the observatory have been provided in the *wdspick.ini* file. The local sidereal time is used to compute the horizontal coordinates of the target stars (azimuth and altitude, displayed in the ADC group).

#### Selection group

This group gathers the commands to navigate through the target list. The CNT field gives the total number of selected entries and the index of the currently selected entry. The other fields display the information retrieved from the WDS for this entry. For stars listed in the 6th Catalog of Orbits, some orbital informations are also given (orbit grade, reference, and the predicted separation and position angle, computed from the ephemerides given in the catalog and the current date).

In the text section at the bottom of the group, WdsPick can also display information related to previous measurements of the selected target. This is useful, for example, to avoid re-measuring a given star

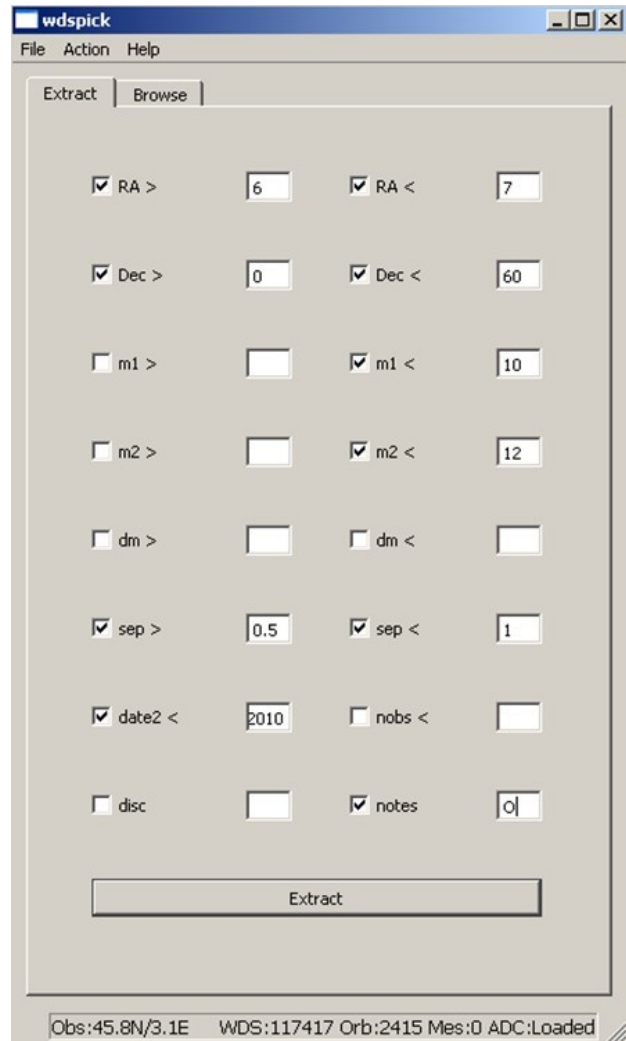


Figure 3. Building a target list with the Extract tab.

which has been recently successfully measured or, on the contrary, to suggest a new measurement if the previous ones have been noted as dubious or imprecise. For this, the list of such previous measurements can be provided in the so-called MES file. The name of this file is specified in the *wdspick.ini* file. Its format is detailed in Section *Parameterizing and Customizing*. The number of entries currently available in the MES file is displayed in the status line of the application after the "Mes:" indication.

The **Next** and **Prev** buttons can be used to navigate freely in the target list.

Once a connection has been established between WdsPick and the SkyChart application (see below),

(Continued on page 538)

## User's Guide to WdsPick

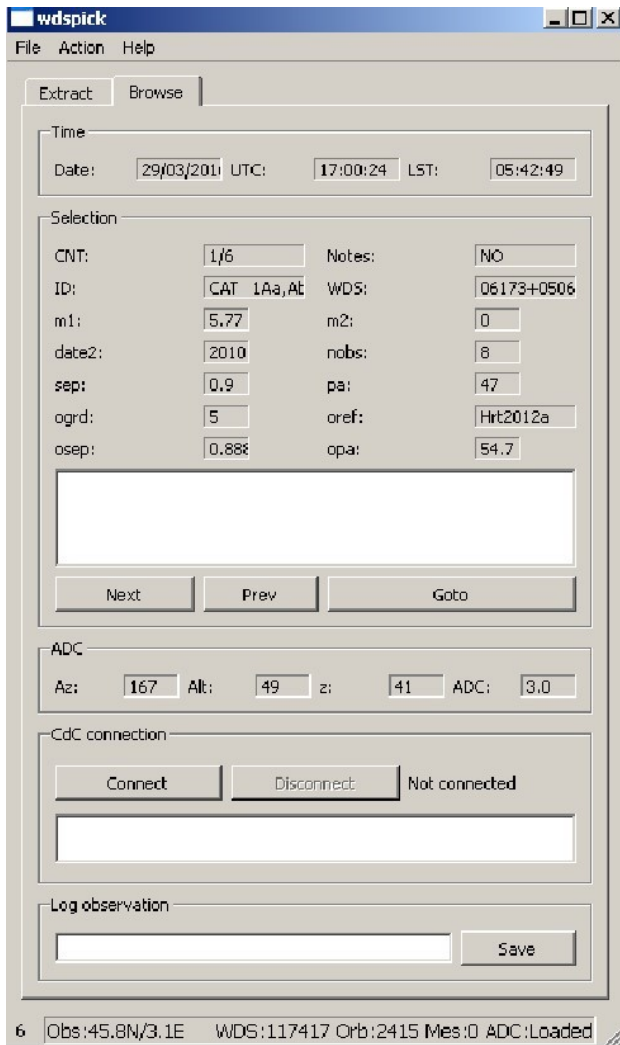


Figure 4. The *Browse* tab obtained after clicking the *Extract* button in Figure 3.

the *Goto* button instructs SkyChart to point to the current selection (as shown in Figure 1).

### ADC group

WdsPick integrates a rudimentary mechanism for simplifying the usage of an atmospheric dispersion corrector (ADC) when observing or imaging double stars at high spatial resolution. With such a device, the angle between the rotating prisms (which controls the amount of correction) must be adjusted according to the altitude (or equivalently the zenithal distance) of the observed star. If the relation between the zenithal distance and the corresponding ADC setting is known (it can be established either theoretically or experimentally) and listed in the ADC file (the name of this file is also specified in the *wdspick.ini*), WdsPick will display the cor-

responding value in the *ADC* field. The availability of ADC data is signaled in the status bar of the application after the 'Adc:' indication. In any case, WdsPick will display the altitude, zenithal distance and azimuth of the current selection. The latter (azimuth) can be useful, for instance, in order to prevent crossing the local meridian when pointing star (which, with certain types of telescope mounts can trigger unwanted movements).

### Cdc Connection group

This group controls the connection between the WdsPick and SkyChart applications. Connection is established using TCP sockets. Connection is requested by clicking on the *Connect* button and can be closed by clicking on the *Disconnect* button. The small text field just below displays relevant messages issued by the SkyChart application. Note that the SkyChart application can be launched before or after WdsPick, the only important point being that it is actually running (and not already connected on the specified address/port) when WdsPick initiates the connection. It is recommended to close the connection (by clicking the *Disconnect* button before quitting one of the applications).

### Log group

This group controls writing to the observing session log. Entering a comment in the text field and clicking on the *Save* button automatically adds a line to the log file containing the name of the current selection (if applicable), the current time and the comment. The name of the log file is "*<prefix>YY-MM-DD.log*", where *<prefix>* is specified in the *wdspick.ini* file (default is "*wdspick\_*"). This file is always written in the directory containing the WdsPick executable. An example of log file is given in the next section.

## Parameterizing and Customizing

WdsPick relies on several external files for correct / optimal operation. All of these files are regular text files and can be freely viewed and/or edited

### The *wdspick.ini* file

This file is mandatory and must be located in the directory containing the application executable. It contains the main parameters of the application, in the form "*<parameter\_name> = <value>*" (one parameter per line). Valid parameters are (with default value if not found in the .ini file)

- **wds\_file** : path to the file containing the WDS catalog (default : *wds.txt*)
- **orb\_file** : path to the file containing the 6th Orbit catalog (default : *orb.txt*)
- **wds\_cat\_index** : number of the catalog for dou-

## User's Guide to WdsPick

ble stars under SkyChart (default : 5)

- **cdc\_tcp\_addr** : IP address for connecting to SkyChart (default : *127.0.0.1*)
- **cdc\_tcp\_port** : port number for connecting to SkyChart (default : *3292*)
- **mes\_file** : path to the file containing the previous measurements (default : *mesures.txt*)
- **adc\_file** : path to the file containing the ADC settings (default : *adc.txt*)
- **log\_file\_prefix** : prefix for naming the log file (cf Sec. "Log Group") (default : *\_wdspick*)
- **launch\_cdc\_on\_start** : if "yes", WdsPick automatically launches SkyChart when starting (default : *no*)
- **cdc\_path** : path to SkyChart application, when launched from WdsPick (default : *C:\Program Files\Ciel\skychart.exe*)
- **cdc\_args** : arguments to pass to the SkyChart application, when launched from WdsPick (default : *none*)
- **obs\_long** : longitude of the observatory (floating point format, negative for east) (default : *0.0*)
- **obs\_lat** : latitude of the observatory (floating point format, negative for south) (default : *45.0*)

File paths can be specified in absolute or relative format. In the latter case, they are relative to the directory containing the WdsPick executable.

An example of *wdspick.ini* file is given in Listing 1.

### The WDS file

This file is mandatory. It is an image of the WDS catalog, in text format. It can be generated by first downloading the catalog from USNO web site (<http://ad.usno.navy.mil/wds/Webtextfiles/wdsnewframe.html>) and saving its contents in text format (select all, copy, paste into text editor). For convenience, the distribution includes a copy of the latest catalog (March 2016).

An excerpt of the WDS file included in the distri-

```

...
07598+1341STF1170      1830 2011   52  97 107   2.2   2.4  8.74  9.09 F5      -011-002 -011-002 +14 1801      075945.52+134119.9
07598+0029BAL1128      1893 1999    3  85  86  17.9  17.9  8.7  12.2 A0      +000+005           +00 2150  D 075950.72+002847.5
07598-0311HJ   75      1825 2000   3 270 275  25.0  25.4 11.43 11.4      -001+001           D 075953.80-025219.4
...

```

Listing 2. Excerpt of the file *wds.txt* included in the distribution.

```

00024+1047 A 1249AB      4   Zir2003      69.7  0.208   68.7  0.222   67.8  0.236   67.0  0.250   66.3  0.263
00026-0829 A 428        4   Tok2015c     322.5  0.121  317.3  0.115  311.8  0.111  305.7  0.107  299.3  0.104
00046+4206 CHR 122Aa,Ab  4   Cve2008a     311.4  0.114  309.2  0.121  307.2  0.127  305.4  0.133  303.8  0.139

```

Listing 3. Excerpt of the file *orb.txt* included in the distribution.

bution is given in Listing 2.

```

wds_file = wds.txt
orb_file = orb.txt
wds_cat_index = 5
cdc_tcp_addr = 127.0.0.1
cdc_tcp_port = 3292
mes_file = mesures.csv
log_file_prefix = wdspick_
launch_cdc_on_start = no
cdc_path = C:\Program Files\Ciel\skychart.exe
cdc_args =
obs_long = -3.0760
obs_lat = 45.7956
adc_file = adc.txt

```

Listing 1. An example of the *wdspick.ini* file.

### The ORB file

This file is optional, but strongly recommended. It is an image of the 6th Catalog of Orbits, in text format. As for the WDS file, it can be generated by first downloading the catalog USNO web site (<http://ad.usno.navy.mil/wds/orb6/orb6ephem.html>) and then saving its contents in text format (select all, copy, paste into text editor). For convenience, the distribution also includes a copy of the latest catalog (march 2016).

An excerpt of the ORB file included in the distribution is given in Listing 3.

### The MES file

This file is optional. It should contain a list of previous observations to be displayed when a star is selected in the target list. Observations must be listed one per line, with each line having the form :

ID; DATE; COMMENT

where

- ID is the WDS discoverer+components designation of the star (ex: "ES 2543AC", "A 1248", ...)
- DATE is the date of the observatio, in decimal format (ex: 2015.576)
- COMMENT is any associated comment

An example of MES file is given in Listing 4.

## User's Guide to WdsPick

```
...
STF 60AB;2009.022;Mewlon 210
STF 60AE;2009.022;Mewlon 210
STF 73AB;2013.904;C11, imprecise
STF 73AB;2013.918;C11, ok
...
```

Listing 4. Excerpt of a measurement file.

### The ADC file

This file is optional. It should contain a list of zenithal distances and corresponding ADC settings to be displayed a star is selected in the target list. Correspondances must be listed one per line, with each line having the form :

Z;R

where

- Z is the zenithal distance, ranging from 0 to 90°, by steps of 1°
- R is the corresponding ADC setting (in decimal format).

### The LOG file

This file is generated by WdsPick. It is filled whenever the user enters some comments in the text field of the Log group and click the [Save](#) button.

An example of LOG file is given in Listing 5.

### Related Work

Several tools have been developed for extracting data from the WDS catalog and building target lists, such as S. Caille's website [doublestars.free.fr](http://doublestars.free.fr) [4] (in french, no longer maintained), D. Chiron's WdsTool [5], T. Bryant's tool [6] or the StelleDoppie database [7]. Because manually copying identifiers or coordinates from between applications can be tedious and error prone, we think that WdsPick offers a more integrated and practical solution. Moreover, since all the required data is available on disk, it does not require an Internet connexion, as do these programs.

### Availability

WdsPick is available in binary form for Windows and Mac OS X platforms from the author's web site at the following URL : <http://www.astrosurf.com/legalet/Astro/WdsPick.html>

```
2016-02-05 20-04-18: seeing=4/10 transparency=2/5. Starting..
2016-02-05 20-06-28: HDS 575: no companion viewed
2016-02-05 20-10-38: A 1839: ok +ref
2016-02-05 20-18-26: A 2034: ok +ref
2016-02-05 20-34-31: D 6: ok adc=1.5
2016-02-05 20-39-05: STT 95: ok texp=10ms
```

Listing 5. Example of session log file.

### Acknowledgments

Development of the WdsPick software has been made possible by the availability of Washington Double Star Catalog [1], the Sixth Catalog of Orbits of Visual Binary Stars [3], both maintained at the U.S. Naval Observatory ([www.usno.navy.mil/USNO](http://www.usno.navy.mil/USNO)), and of the SkyChart/Cartes du Ciel application [2].

### References

- [1] <http://ad.usno.navy.mil/wds>
- [2] <http://www.ap-i.net/skychart/en/start>
- [3] <http://ad.usno.navy.mil/wds/orb6>
- [4] <http://doublestars.free.fr>
- [5] [http://wdstool.com/wds\\_index\\_us.php](http://wdstool.com/wds_index_us.php)
- [6] T.V. Bryant., "An Online Tool that Searches the WDS", *JDSO*, **11**, 164-166, 2015.
- [7] <http://stelledoppie.goaction.it>

# Measurements of Wide Tycho Double Stars in Orion

Wilfried R.A. Knapp

Vienna, Austria

[wilfried.knapp@gmail.com](mailto:wilfried.knapp@gmail.com)

Mark McPhee

Austin, Texas

[dr.mark.mcphee@gmail.com](mailto:dr.mark.mcphee@gmail.com)

**Abstract:** About 25 TDS objects in Orion with separation of 1.5" or larger remained at the beginning of 2016 in the WDS catalog without confirmation while 10 are listed as confirmed. Several of the so far unconfirmed objects have now been successfully observed while most of the remaining objects are to be suspected as being bogus as the evidence suggests single stars. The number of confirmed TDS objects of this separation range in Orion is greater than in the other constellations we have studied so far.

## Introduction

At the beginning of 2016, McPhee joined Chris Thuemen's "Double Star Imaging Group" with an equipment portfolio that Knapp thought potentially able to resolve TDS objects with separation less than 1.5". McPhee was contacted for a test run with objects with somewhat larger separation as a starter. So far, unconfirmed TDS objects with separation 1.5" or larger are to be found ample in all constellations. In Orion, 20 such objects were selected plus TDS3407 as one already confirmed object as reference. These are listed in Table 1.

## Further Research

A single image was taken by Knapp for most of the selected objects with the iT27 using a 3s exposure time, but a few were missed due to ongoing bad weather along with Orion fading in altitude quickly. The RA/Dec coordinates resulting from plate solving with UCAC4 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  $\text{SQRT}(dRA^2 + dDec^2)$  with dRA and dDec as aver-

age RA and Dec plate solving errors. Err\_PA is the error estimation for PA calculated as  $\arctan(\text{Err\_Sep}/\text{Sep})$  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  $(dVmag^2 + (2.5 * \text{Log}_{10}(1 + 1/\text{SNR}))^2)$  with dVmag as the average Vmag error over all used reference stars and SNR is the signal to noise ratio for the given star.

Knapp also checked 2MASS J-band images for evidence proven to be helpful down to 1.5" separation depending on delta\_m.

Additionally, McPhee observed a number of the objects visually and also took some photographic images for visualisation.

The results are given in Table 2.

## Images for Visualization

Figure 1 is of some of the TDS objects imaged by McPhee. Figure 2 shows 2MASS images for two objects.

### Measurements of Wide Tycho Double Stars in Orion



Figure 1. McPhee's images for some of the measured objects

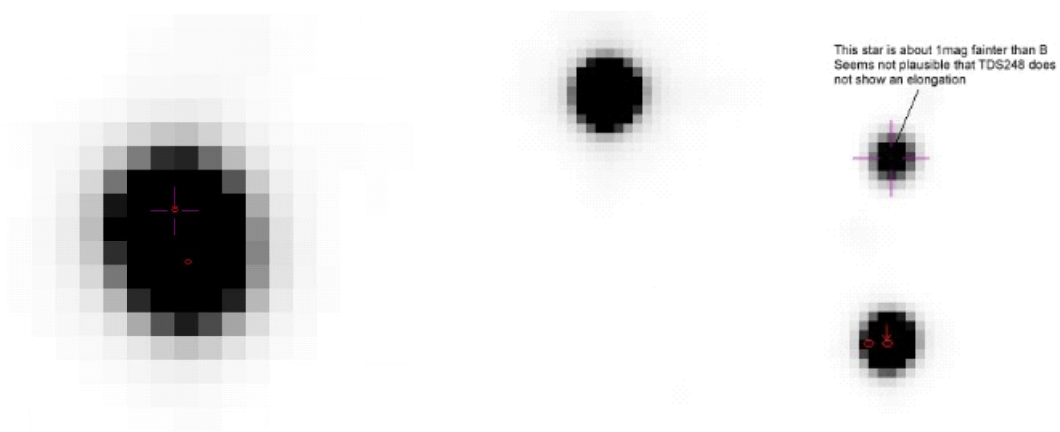


Figure 2. 2MASS J-band for TDS3010 and TDS248 with TDSC positions

## Measurements of Wide Tycho Double Stars in Orion

Table 1. WDS catalog data (based on Fabricius et al. 2002) at the beginning of 2016 for the selected unconfirmed TDS objects in Ori with separation of 1.5 arcseconds or larger

Name	Comp	WDS ID	RA	Dec	Sep	M1	M2	PA
TDS185	AB	05366-0625	05:36:37.810	-06:25:30.3	1.5	10.14	12.10	195
TDS211	AB	05591+1846	05:59:08.690	+18:45:36.6	1.8	10.18	11.94	181
TDS241	AB	06207+0857	06:20:39.380	+08:57:04.7	2.1	9.49	11.27	92
TDS248	AB	06244+1128	06:24:23.640	+11:27:42.2	2.0	9.40	11.82	94
TDS2965	AB	04474+0907	04:47:23.540	+09:06:55.7	1.5	10.59	11.62	332
TDS3010	AB	04561+0555	04:56:03.281	+05:54:51.3	2.2	11.54	12.22	194
TDS3160	AB	05220+0319	05:22:00.780	+03:18:50.2	1.5	9.50	11.72	219
TDS3167	AB	05228-0804	05:22:46.370	-08:04:21.2	1.7	11.63	12.01	138
TDS3407	AB	05535-1025	05:53:29.821	-10:24:33.8	2.3	11.73	11.88	80
TDS3443	AB	05569+1859	05:56:51.250	+18:58:51.1	2.0	11.30	12.38	154
TDS3535	AB	06044+1257	06:04:26.849	+12:57:11.9	2.2	11.14	12.03	206
TDS3542	AB	06053+2028	06:05:16.810	+20:27:58.9	1.7	10.27	11.89	274
TDS3545	AB	06055+1742	06:05:27.460	+17:41:32.7	2.1	11.26	11.97	217
TDS3550	AB	06057+2039	06:05:44.330	+20:39:13.5	1.7	10.80	11.70	138
TDS3562	AB	06069+1428	06:06:52.739	+14:27:42.4	2.2	9.66	12.08	323
TDS3613	AB	06115-0343	06:11:29.320	-03:43:20.6	2.1	11.50	11.51	179
TDS3661	AB	06149+0822	06:14:53.899	+08:22:02.3	2.1	11.66	11.97	38
TDS3669	AB	06153+1740	06:15:18.060	+17:39:41.2	1.7	9.85	11.71	231
TDS3674	AB	06156+0706	06:15:34.190	+07:05:30.7	1.5	11.78	12.26	94
TDS3679	AB	06158-0145	06:15:50.941	-01:45:18.5	2.0	11.09	11.89	143
TDS3684	AB	06161+0935	06:16:04.649	+09:35:09.2	2.6	11.22	11.31	159

### Summary

The veracity of several objects from this study remains unresolved due to inconclusive results. While a few objects were missed, 4 double stars out of 17 were confirmed. Compared with the TDS record in other constellations (see Knapp, Gould 2016), this was a rather positive result. Next observing season should witness completion of this project. Imaging upgrades by one of the authors (McPhee) allowing for resolution of TDS objects below 1.5" separation is in progress—this should allow a more detailed analysis of these objects within the constellation of Orion.

### Acknowledgements

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

- Washington Double Star Catalog as data source for the selected objects
- Mark McPhee's equipment: Telescope: 381mm Dobsonian reflector (Obsession brand) with 1732mm focal length. Camera: Nikon D5100 DSLR. Located in Bee Cave, Texas. Elevation 280m
- iTelescope: Images were taken with the iT27: 700mm CDK with 4531mm focal length. CCD:

FLI PL09000. Resolution 0.53 arcsec/pixel. V-filter. Located in Siding Spring, Australia. Elevation 1122m

- 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 and for high precision plate solving
- Tycho Double Star catalog for counterchecks
- 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 v4.8.2.405 for astrometry and photometry measurements

(Continued on page 546)

**Measurements of Wide Tycho Double Stars in Orion**

*Table 2: Astrometry and photometry results for the selected TDS components in Ori. Date is the Bessel epoch in 2016 and N is the number of images 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).*

Name		RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date 2016	N	Notes
TDS 185	A	05 36 37.805	-06 25 30.46	0.15	0.14	-	0.205	-	-	10.322	0.100	236.21	0.10	.155	1	1
	B	-	-							-	-	-				
TDS 241	A	06 20 39.373	08 57 04.75	0.18	0.17	-	0.248	-	-	9.644	0.070	150.50	0.07	.160	1	2
	B	-	-							-	-	-				
TDS 248	A	06 24 23.628	11 27 42.06	0.18	0.20	-	0.269	-	-	9.165	0.100	202.34	0.10	.160	1	3
	B	-	-							-	-	-				
TDS2965	A	04 47 23.575	09 06 55.40	0.22	0.15	-	0.266	-	-	10.278	0.090	170.85	0.09	.155	1	4
	B	-	-							-	-	-				
TDS3010	A	04 56 03.219	05 54 50.60	0.16	0.17	2.100	0.233	181.221	6.342	11.611	0.091	85.40	0.09	.155	1	5
	B	04 56 03.216	05 54 48.50							12.136	0.092	64.42				
TDS3160	A	05 22 00.744	03 18 49.85	0.17	0.17	-	0.240	-	-	9.259	0.100	332.23	0.10	.155	1	6
	B	-	-							-	-	-				
TDS3167	A	05 22 46.366	-08 04 21.10	0.15	0.14	-	0.205	-	-	12.227	0.071	93.59	0.07	.155	1	7
	B	-	-							-	-	-				
TDS3407	A	05 53 29.840	-10 24 33.96	0.18	0.20	2.029	0.269	81.496	7.555	11.572	0.082	57.15	0.08	.160	1	8
	B	05 53 29.976	-10 24 33.66							11.626	0.082	54.36				
TDS3443	A	05 56 51.214	18 58 50.83	0.17	0.19	-	0.255	-	-	11.160	0.091	96.33	0.09	.160	1	9
	B	-	-							-	-	-				
TDS3535	A	06 04 26.841	12 57 11.83	0.17	0.19	-	0.255	-	-	11.144	0.131	77.08	0.13	.160	1	10
	B	-	-							-	-	-				
TDS3545	A	06 05 27.460	17 41 32.49	0.21	0.17	-	0.270	-	-	11.453	0.091	74.08	0.09	.160	1	11
	B	-	-							-	-	-				
TDS3550	A	06 05 44.334	20 39 13.41	0.19	0.17	-	0.255	-	-	10.705	0.114	35.78	0.11	.172	1	12
	B	-	-							-	-	-				
TDS3562	A	06 06 52.715	14 27 42.29	0.24	0.20	-	0.312	-	-	9.593	0.080	136.32	0.08	.160	1	13
	B	-	-							-	-	-				
TDS3613	A	06 11 29.315	-03 43 20.80	0.15	0.14	2.050	0.205	172.025	5.716	11.383	0.061	107.52	0.06	.160	1	14
	B	06 11 29.334	-03 43 22.83							12.191	0.062	62.15				
TDS3661	A	06 14 53.997	08 22 03.69	0.15	0.16	-	0.219	-	-	12.617	0.072	63.72	0.07	.160	1	15
	B	-	-							-	-	-				
TDS3674	A	06 15 34.186	07 05 30.74	0.15	0.16	-	0.219	-	-	11.501	0.091	103.07	0.09	.155	1	16
	B	-	-							-	-	-				
TDS3679	A	06 15 50.932	-01 45 18.45	0.14	0.16	1.851	0.213	142.586	6.553	10.885	0.110	106.60	0.11	.160	1	17
	B	06 15 51.007	-01 45 19.92							11.233	0.111	101.91				
TDS3684	A	06 16 04.636	09 35 09.14	0.14	0.16	2.675	0.213	158.593	4.545	11.004	0.071	101.50	0.07	.160	1	18
	B	06 16 04.702	09 35 06.65							11.289	0.071	87.43				

## Measurements of Wide Tycho Double Stars in Orion

### Table 2 Notes

1. iT27 1x3s. No resolution, not even hint of an elongation. Check 2MASS J-band image not conclusive, primary might be too bright for any hint of the faint companion. But measured magnitude no good match with calculated combined magnitude. McPhee: appears to be a single star (289x). Bogus assumed.
2. iT27 1x3s. Star disk slightly deformed but no serious hint for a double, primary might be too bright for resolution with iT27. Measured magnitude no good match with calculated combined magnitude. 2MASS J-band image also negative. McPhee: no elongation detected at any magnification (173x, 231x, 266x). Bogus assumed.
3. iT27 1x3s. Star disk slightly deformed but no serious hint for a double, primary might be too bright for resolution with iT27. Measured magnitude would be rather good match with calculated combined magnitude. Check 2MASS J-band image negative. McPhee: no elongation detected at any magnification (173x, 231x, 266x). Inconclusive result.
4. iT27 1x3s. Star disk with no distinctive elongation. Measured combined magnitude would be rather good match with calculated combined magnitude. Check 2MASS J-band image negative. McPhee: a single star at 173x, but appears extended or pointy at 231x. Stars appear to be closer than 1.5" or the magnitude of secondary is fainter than 11.6 despite WDS listing data being similar to TDS 3550. Overall result is inconclusive.
5. iT27 1x3s. Overlapping star disks, distinctive elongation/rod - but measurements due to overlap probably somewhat imprecise. Check 2MASS J-band image positive. McPhee: resolved at 173x with magnitudes and position angle matching WDS data; second, separate observation confirms resolution at 289x. Confirmed.
6. iT27 1x3s. Star disk slightly deformed but no serious hint for a double, primary might be too bright for resolution with iT27. Measured magnitude would be rather good match with calculated combined magnitude. Check 2MASS J-band image negative. McPhee: appears to be a single star (289x). Inconclusive result.
7. iT27 1x3s. No resolution, not even hint of an elongation. Check 2MASS J-band image negative. McPhee: no elongation detected at any magnification (173x, 231x, 266x). Bogus.
8. iT27 1x3s. Distinctive rod. Sep bit smaller as WDS catalog listed, else data rather confirmed. Listed in WDS catalog with confirmation. Check 2MASS J-band image positive. McPhee: resolved at 173x to two evenly matched stars with correct pa. Image confirms duplicity. Confirmed.
9. iT27 1x3s. Star disk slightly deformed but no serious hint for a double. Measured magnitude would be rather good match with calculated combined magnitude but check 2MASS J-band image also negative. McPhee: no elongation detected at any magnification (173x, 231x, 266x). Bogus assumed.
10. iT27 1x3s. Star disk slightly elongated, but not distinctive - rather tracking problem. Calculated combined magnitude no good match with measured magnitude. Countercheck 2MASS J-band image: Obviously single star. McPhee: possibly rod shaped (extended) at 173x and 289x; seems to be too close to be 2.2". Image does not show any elongation. Bogus assumed.
11. iT27 1x3s. Star disk slightly elongated, but not distinctive - rather tracking problem. Calculated combined magnitude not good match with measured magnitude. Countercheck 2MASS J-band image: Obviously single star. McPhee: conflicting data at 173x (possibly resolved) and 289x (single star) during separate observing sessions. Image does not show any elongation. Bogus assumed.
12. iT18 1x3s. Star disk slightly elongated, but not distinctive - rather tracking problem. Calculated combined magnitude no good match with measured magnitude. Countercheck 2MASS J-band image: Obviously single star. McPhee: doubtful duplicity at 173x; possible hints of elongation in correct p at 231x; suspected elongation at 289x. Image does not show any elongation. Bogus assumed.
13. iT27 1x3s. Star disk slightly deformed but no serious hint for a double. Measured magnitude would be rather good match with calculated combined magnitude but check 2MASS J-band image distinctive negative. McPhee: no elongation at 173x; possibly extended (pointy) at 231x; possibly elongated at 266x. Bogus assumed.
14. iT27 1x3s. Clear elongation. Check 2MASS J-band image positive. McPhee: suspected elongation at 173x, but magnitude seems a bit low at 11.5 and separation is too tight for 2.1"; elongation suspected at 266x with averted vision and confirmed at 289x. Image confirms duplicity. Confirmed.
15. iT27 1x3s. No resolution, not even hint of an elongation. Check 2MASS J-band image negative. McPhee: single star at 173x and magnitude seems too faint for a pair of magnitude 11.7, 12 stars; appears to be a single star at 289x, but hard to tell because the system is very faint. Overall result not fully conclusive, but rather bogus assumed.
16. iT27 1x3s. Hint of elongation obviously tracking error. Check 2MASS J-band image also negative. McPhee: possible elongation at 173x; potential rod shape at 171x; most likely extended at 289x as seen with averted vision. Bogus assumed.
17. iT27 1x3s. Clear elongation/rod. Check 2MASS J-band image also positive. McPhee: just resolved at 173x; definitely elongated in correct pa at 289x. Confirmed.
18. iT27 1x3s. Clear elongation/rod. Check 2MASS J-band image also positive. McPhee: easily split at 289x with stars displaying correct pa. Image confirms duplicity. Confirmed.

## Measurements of Wide Tycho Double Stars in Orion

*(Continued from page 543)*

### References:

- R. Buchheim, 2008, "CCD Double-Star Measurements at Altimira Observatory in 2007", *Journal of Double Star Observations*, **4**, 27-31.
- C. Fabricius, E. Høg, V.V. Makarov, B.D. Mason, G.L. Wycoff and S.E. Urban, 2002, "The Tycho Double Star Catalogue", *Astronomy & Astrophysics*, **384**, 180-189.
- Knapp, Wilfried; Gould, Ross – 2016, "Visual Observation and Measurements of some Tycho Double Stars", *Journal of Double Star Observations*, **14**, 427-436.



# Measurements of some Tycho Double Stars – Follow Up Canis Minor and Columba

Ross Gould

Double Star Notes, Australian Sky & Telescope  
Canberra, ACT, Australia  
[rgould1792@optusnet.com.au](mailto:rgould1792@optusnet.com.au)

Wilfried R.A. Knapp

Vienna, Austria  
[wilfried.knapp@gmail.com](mailto:wilfried.knapp@gmail.com)

**Abstract:** As follow up to our report “Visual Observation and Measurements of some Tycho Double Stars” we decided to have a look at some more wider TDS objects in other constellations but to replace the hapless visual observation task by counterchecking with existing Sky Survey images

## Introduction

So far unconfirmed TDS objects are to be found in all constellations so the selected objects are more or less a random choice based on reasonable altitude for imaging with a remote telescope located in Australia. All the selected objects are in the constellations Canis Minor (CMi) or Columba (Col).

## Further Research

One image was taken for the selected objects with iT27 with 3s exposure time. The RA/Dec coordinates resulting from plate solving with UCAC4 reference stars in the 10.5 to 14.5 magnitude range were used to calculate separation and position angle using the formula provided by R. Buchheim (2008).  $Err\_Sep$  is calculated as

$$Err\_Sep = \sqrt{dRA^2 + dDec^2}$$

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

$$Err\_Mag = \sqrt{dVmag^2 + (2.5 \log_{10}(1 + 1/SNR))^2}$$

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 2.

## Counter Check

All these results were visually counterchecked using Sky Survey images as described in Table 3.

An account of the methodology used for 2MASS Sky Survey images, its usefulness and limitations, will be given in a separate short article to appear in JDSO. It was found that, whereas the usual deep magnitude sky survey plates are limited to 5 arcseconds or wider in showing double stars, the IR images of 2MASS, taken in 1997-1999, can show double stars as elongated images down to about 1.5 arcseconds separation with moderate  $\Delta m$  (in IR). AladinLite shows a combined set of 2MASS images, which gives a first assessment. In Figures 1 through 10 are reproduced the J-band 2MASS images or sometimes K-band. Both J-band and K-band

(Continued on page 555)

### Measurements of some Tycho Double Stars – Follow Up Canis Minor and Columba

*Table 1. WDS values per begin of 2016 for the selected unconfirmed TDS/TDT objects in Canis Minor and Columba with separation larger than 1.5 arcseconds*

Name	Comp	WDS ID	RA	Dec	Sep	M1	M2	PA	Con
TDS360	AB	07212+0511	07:21:09.941	+05:11:19.2	1.5	11.33	11.52	148	CMi
TDS403	AB	07437+0743	07:43:40.900	+07:42:40.8	1.5	10.39	11.69	130	CMi
TDS4528	AB	07095+0247	07:09:28.400	+02:47:07.7	1.5	11.22	11.77	256	CMi
TDS4547	AB	07105+0434	07:10:30.830	+04:34:06.2	2.3	11.32	12.70	4	CMi
TDS4690	AB	07182+0906	07:18:09.119	+09:05:32.0	1.6	11.56	11.92	184	CMi
TDS4767	AB	07240+0638	07:24:00.340	+06:38:16.8	3.7	12.49	12.57	207	CMi
TDS4828	AB	07279+0013	07:27:53.050	+00:12:45.7	1.5	11.59	12.13	229	CMi
TDS4900	AB	07319+0004	07:31:55.950	+00:04:06.9	1.8	11.20	12.36	259	CMi
TDS4967	AB	07355+0256	07:35:30.270	+02:56:19.7	2.3	10.85	12.02	146	CMi
TDS5012	AB	07388+0626	07:38:48.360	+06:25:44.4	2.4	11.52	12.68	156	CMi
TDS5052	AB	07409+1108	07:40:54.989	+11:08:27.8	1.9	11.70	12.03	255	CMi
TDS5065	AB	07413+0452	07:41:16.051	+04:52:02.4	1.5	11.32	12.13	34	CMi
TDS5087	AB	07422+0431	07:42:09.370	+04:31:17.4	2.2	11.36	12.50	179	CMi
TDS5571	AB	08091+0212	08:09:06.021	+02:12:08.7	1.6	10.75	11.95	305	CMi
TDS3063	AB	05061-4152	05:06:03.931	-41:51:52.1	2.0	10.09	12.09	326	Col
TDS3113	AB	05132-4152	05:13:10.791	-41:52:03.2	1.5	11.62	11.92	36	Col
TDS3176	AB	05240-3719	05:24:02.210	-37:19:05.9	1.5	11.37	12.11	216	Col
TDS3297	AB	05428-2919	05:42:47.701	-29:18:33.5	2.0	10.19	12.36	144	Col
TDS3391	AB	05525-4012	05:52:28.400	-40:11:44.8	2.0	11.55	12.34	203	Col
TDS3529	AB	06038-3307	06:03:50.440	-33:06:38.2	2.5	11.75	12.01	160	Col
TDS3586	AB	06088-2806	06:08:48.569	-28:05:30.0	2.2	11.15	12.69	128	Col
TDS3614	AB	06115-4151	06:11:31.110	-41:50:49.8	1.7	11.45	13.26	296	Col
TDS3731	AB	06194-3322	06:19:26.080	-33:22:18.4	2.3	11.22	12.76	335	Col
TDS3846	AB	06277-3316	06:27:43.730	-33:15:51.6	1.8	11.36	13.04	224	Col
TDS3852	AB	06279-4140	06:27:56.030	-41:40:07.8	1.8	11.48	12.17	227	Col
TDS3891	AB	06313-3438	06:31:19.950	-34:37:44.5	2.1	11.49	12.24	272	Col

Measurements of some Tycho Double Stars – Follow Up Canis Minor and Columba

Table 2. Astrometry and photometry results for the selected TDS/TDT components in Cmi and Col. Date is the Bessel epoch of the observation and N is the number of images used for the reported values. iT27 in the Notes column indicates the telescope used with number of images and exposure time given (Specifications of iT27. See Acknowledgements).

Name	RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
TDS 360	A 07 21 09.888	05 11 20.11							10.856	0.111	63.65				iT27 1x3s. Overlapping star disks, photometry results questionable because sides being similar bright. Astrometry result plausible
	B 07 21 09.982	05 11 18.64	0.21	0.19	2.033	0.283	136.311	7.931	10.891	0.111	82.11	0.11	2016.117	1	
TDS 403	A 07 43 40.834	07 42 41.50							10.639	0.080	141.59				iT27 1x3s. Overlapping star disks, photometry results questionable because sides being similar bright. Astrometry result plausible
	B 07 43 40.945	07 42 40.01	0.18	0.18	2.223	0.255	132.084	6.532	10.742	0.080	150.94	0.08	2016.117	1	
TDS 4528	A 07 09 28.395	02 47 07.57							11.227	0.101	105.45				iT27 1x3s. No hint of elongation, bogus assumed
	B -	-	0.20	0.17	-	0.262	-	-	-	-	-	0.10	2016.117	1	
TDS 4547	A 07 10 30.803	04 34 06.30							11.460	0.071	114.12				iT27 1x3s. Smallest hint of elongation, but not conclusive. Bogus assumed or at least far smaller separation than 2.3"
	B -	-	0.21	0.18	-	0.277	-	-	-	-	-	0.07	2016.117	1	
TDS 4690	A 07 18 09.096	09 05 31.97							11.814	0.112	58.84				iT27 1x3s. Hint of elongation, but of unequal bright pair
	B 07 18 09.094	09 05 30.37	0.11	0.11	1.600	0.156	181.061	5.552	12.554	0.117	25.94	0.11	2016.237	1	
TDS 4767	A 07 24 00.338	06 38 16.82							12.012	0.081	91.98				iT27 1x3s. Only "primary" resolved, no trace of a 3.7" companion, bogus assumed. Nearby UCAC4-484-036641 optical pair
	B -	-	0.17	0.16	-	0.233	-	-	-	-	-	0.08	2016.117	1	
UCAC4-484-036641	A 07 24 21.012	06 40 32.06							10.762	0.081	115.04				iT27 1x3s. Optical pair near TDS4767
	B 07 24 20.812	06 40 30.69	0.17	0.16	3.280	0.233	245.308	4.072	12.578	0.089	26.82	0.08	2016.117	1	
TDS 4828	A 07 27 53.039	00 12 45.56							11.716	0.101	70.53				iT27 1x3s. No hint of elongation, bogus assumed
	B -	-	0.18	0.16	-	0.241	-	-	-	-	-	0.10	2016.117	1	
TDS 4900	A 07 31 55.935	00 04 06.90							11.289	0.071	83.70				iT27 1x3s. No hint of elongation, bogus assumed
	B -	-	0.18	0.18	-	0.255	-	-	-	-	-	0.07	2016.117	1	

Measurements of some Tycho Double Stars – Follow Up Canis Minor and Columba

Table 2(continued) . Astrometry and photometry results for the selected TDS/TDT components in CMI and Col. Date is the Bessel epoch of the observation and N is the number of images used for the reported values. iT27 in the Notes column indicates the telescope used with number of images and exposure time given (Specifications of iT27: See Acknowledgements).

Name	RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
TDS 4967	A 07 35 30.254	02 56 19.58	0.18	0.16	-	0.241	-	-	10.919	0.071	127.10	0.07	2016.117	1	iT27 1x3s. No hint of elongation, bogus assumed
	B	-							-	-					
TDS 5012	A 07 38 48.376	06 25 43.95	0.10	0.10	2.250	0.141	146.195	3.596	11.258	0.111	60.71	0.11	2016.234	1	iT27 1x3s. Distinct elongation, touching/overlapping star disks
	B 07 38 48.460	06 25 42.08							12.512	0.116	29.91				
TDS 5052	A 07 40 54.980	11 08 27.88	0.10	0.12	-	0.156	-	-	12.335	0.081	72.30	0.08	2016.234	1	iT27 1x3s. No hint of elongation, bogus assumed
	B	-							-	-					
TDS 5065	A 07 41 16.052	04 52 02.50	0.17	0.16	-	0.233	-	-	11.284	0.070	136.22	0.07	2016.117	1	iT27 1x3s. No hint of elongation, bogus assumed
	B	-							-	-					
TDS 5087	A 07 42 09.378	04 31 17.20	0.18	0.14	-	0.228	-	-	11.099	0.090	131.96	0.09	2016.117	1	iT27 1x3s. No hint of elongation, bogus assumed
	B	-							-	-					
TDS 5571	A 08 09 06.028	02 12 08.63	0.09	0.12	-	0.150	-	-	10.695	0.051	128.19	0.05	2016.234	1	iT27 1x3s. Hint of elongation in the right direction - but this is the case with all stars in the image, obviously tracking error. Bogus assumed
	B	-							-	-					
TDS 3063	A 05 06 03.975	-41 51 52.12	0.21	0.12	-	0.242	-	-	9.976	0.091	83.75	0.09	2016.120	1	iT27 1x3s. No resolution, not even a hint of an elongation. Bogus assumed
	B	-							-	-					
TDS 3113	A 05 13 10.767	-41 52 02.91	0.19	0.18	1.466	0.262	47.000	10.121	11.154	0.151	79.24	0.15	2016.120	1	iT27 1x3s. Elongation not very distinctive but measurement seems with the exception of PA rather a confirmation of the current WDS catalog data
	B 05 13 10.863	-41 52 01.91							11.168	0.151	83.89				
TDS 3176	A 05 24 02.211	-37 19 05.74	0.20	0.20	1.964	0.283	209.469	8.195	11.140	0.111	71.84	0.11	2016.120	1	iT27 1x3s. Elongation not very distinctive but measurement seems with the exception of mag B rather a confirmation of the current WDS catalog data
	B 05 24 02.130	-37 19 07.45							11.147	0.112	57.10				



### Measurements of some Tycho Double Stars – Follow Up Canis Minor and Columba

Table 3. Results countercheck TDS objects in CMi and Col by Sky Survey images

Name		WDS ID	Notes
TDS360	AB	07212+0511	AladinLite 2MASS elongated image, out of round in PA ~150/330. 2MASS J 1999 clear elongation in approx PA of Tycho. <b>Double.</b>
TDS403	AB	07437+0743	AladinLite 2MASS rather lumpy artefacted image; not useful. 2MASS J 1999 fairly neat symmetrical single image. Some extension to West? 2MASS K 1999 slightly different from J image, but pretty symmetrical. Slight impression of E-W extension. <b>Likely single. Does not fit Tycho numbers; image is overexposed.</b>
TDS4528	AB	07095+0247	AladinLite 2MASS fairly round image, no E-W elongation. 2MASS J 1999 pretty regular symmetrical image. Pixels slightly brighter E than W. However, does not show elongation as well, so <b>probably single.</b>
TDS4547	AB	07105+0434	AladinLite 2MASS slightly out of round but more E-W; likely single. 2MASS J 1999 neat symmetrical single star; no extension; pixels of pretty regular brightness symmetrically. <b>Single.</b>
TDS4690	AB	07182+0906	AladinLite 2MASS slight elongation offset a little from N-S; PA ~200. 2MASS J 1999 Somewhat asymmetrical extended image slightly off N-S line; image suggests PA nearer to ~200. <b>Double.</b> K-band image: Some elongation, PA larger than Tycho, ~190+.
TDS4767	AB	07240+0638	AladinLite 2MASS adjoining star to SSE. Both stars neatly single, nicely round. 2MASS J 1999 Two regular single star images (8.5" pair). Single regular image for TDS4767. <b>Clearly single.</b>
TDS4828	AB	07279+0013	AladinLite 2MASS single nicely round star 2MASS J 1999 pretty regular symmetrical single image; slight variations in pixel brightness, no sign of elongation. <b>Single.</b>
TDS4900	AB	07319+0004	AladinLite 2MASS neat symmetrical round single star. 2MASS J 1998 regular quite symmetrical single image. Some pixel brightness variation. 2MASS K 1998 fairly symmetrical image, some pixel brightness variations. Any extension hinted at is N-S, not E-W. <b>Single.</b>
TDS4967	AB	07355+0256	AladinLite 2MASS quite neat and symmetrical round star image. 2MASS J 1999 pretty regular single-looking image. Slight variations in pixel brightness, but no sign of elongation. 2MASS K 1999 Similar to J image, but pixel brightness more regular. No elongation anywhere. <b>Clearly single.</b>
TDS5012	AB	07388+0626	AladinLite 2MASS clearly elongated slightly unequal double overlapped. 2MASS J 1999 clearly elongated double in Tycho PA.... <b>Double.</b>
TDS5052	AB	07409+1108	AladinLite 2MASS v slightly out of round star, but not in PA ~255; perhaps ~320/330. 2MASS J 1999 fairly regular, symmetrical single-looking image. 2MASS K 1999 slightly different pattern of pixel brightness; but not a good fit for Tycho. <b>Likely single.</b>
TDS5065	AB	07413+0452	AladinLite 2MASS pretty round symmetrical single image. 2MASS J 1999 fairly symmetrical image, slight hint of elongation E-W (not in Tycho PA). 2MASS K 1999 fairly regular symmetrical image, likely single; slightly different from J. <b>Likely single.</b>
TDS5087	AB	07422+0431	AladinLite 2MASS fairly good symmetrical single image. 2MASS J 1999 fairly symmetrical single image. K-band image similar. <b>Likely single.</b>
TDS5571	AB	08091+0212	AladinLite 2MASS pretty good round star. 2MASS J 1997 quite symmetrical single image. K-band image similar, looks single. <b>Likely single.</b>
TDS3063	AB	05061-4152	AladinLite 2MASS nearly circular star image. 2MASS J 1998 fairly regular (symmetrical) image, <b>single.</b>
TDS3113	AB	05132-4152	AladinLite 2MASS slight elongation in PA ~40/220. 2MASS J 1998 some elongation clearly present; K band similar. <b>Probably double,</b> though near the limit of detectability.

Table 3 concludes on next page.

### Measurements of some Tycho Double Stars – Follow Up Canis Minor and Columba

Table 3 (conclusion). Results countercheck TDS objects in CMi and Col by Sky Survey images

Name		WDS ID	Notes
TDS3113	AB	05132-4152	AladinLite 2MASS slight elongation in PA ~40/220. 2MASS J 1998 some elongation clearly present; K band similar. <b>Probably double</b> , though near the limit of detectability.
TDS3176	AB	05240-3719	AladinLite 2MASS slightly out of round/oval in PA ~210/030 2MASS J 1999 clear elongation NW/SE. <b>Double.</b>
TDS3297	AB	05428-2919	AladinLite DSS 2MASS no sign of double; round. 2MASS J 1998 quite regular symmetrical image. Appears <b>single</b> .
TDS3391	AB	05525-4012	AladinLite 2MASS fairly circular image. 2MASS J 1999 Image roughly symmetrical, but brighter to N and E. K-band image similar. <b>Likely single.</b> <b>Also:</b> Star nearby SSW is marked double by UCAC. It shows asymmetry in K band image. Perhaps 2.0" in PA ~125/305. It is TYC 7602-931-1: on AladinLite 2MASS hint only of elongation. Does this suggest an ID problem? - a need to establish which is meant to be the double? However this ucac4 double does not fit the Tycho PA.
TDS3529	AB	06038-3307	AladinLite DSS 2MASS some elongation (egg shape) in PA ~150. 2MASS J 1999 distinct elongation in PA ~160; obvious contrast with nearby star to SE which is single. <b>Double.</b>
TDS3586	AB	06088-2806	AladinLite 2MASS near-circular image, faint hint of elongation N-S? 2MASS J 1999 symmetrical image but with slight brightness variation suggests slight E-W asymmetry. K band similar. Assessed <b>single</b> .
TDS3614	AB	06115-4151	AladinLite 2MASS fairly regular round image. 2MASS J 1997 image pretty symmetrical. <b>Likely single.</b>
TDS3731	AB	06194-3322	AladinLite 2MASS fairly round single. 2MASS J 1999 Reasonably symmetrical image; slightly brighter pixels to West. K image also symmetrical and less pixel brightness variation. <b>Probably single.</b>
TDS3846	AB	06277-3316	AladinLite 2MASS circular single. 2MASS J 1999 Symmetrical, but hint of N-S elongation on brightness only, which does not fit Tycho PA. <b>Likely single.</b>
TDS3852	AB	06279-4140	AladinLite 2MASS circular disc, single. 2MASS J 1999 looks single, though with slight N-S asymmetry of pixel brightness that does not fit Tycho PA. No elongation as such. K image similar to J. <b>Single.</b>
TDS3891	AB	06313-3438	AladinLite 2MASS nicely round star. 2MASS J 1999 Symmetrical image, but impression of brightness pattern N-S brighter, E-W dimmer (does not fit Tycho PA). K band image similar to J. <b>Likely single.</b>

### Measurements of some Tycho Double Stars – Follow Up Canis Minor and Columba

Images from 2MASS survey: data is from Tycho in WDS for ~1991. First, some genuine pairs, including one long known, RST 1289, of similar magnitudes (10.98, 11.98) to many Tycho pairs.



Figure 1: RST 1289  
1.9" PA 111

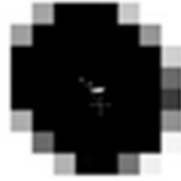


Figure 2: TDS 360  
1.5" PA 148

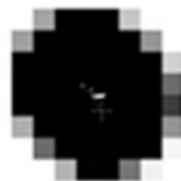


Figure 3: TDS3113  
1.5" PA 036



Figure 4: TDS3176  
1.5" PA 216

Then, some of the pairs assumed bogus from image examination, plus TDS4547 where there was ambiguity in the new image. These are 2MASS J images.



Figure 5: TDS4547  
2.3" PA 004



Figure 6: TDS4767  
3.7" PA 207

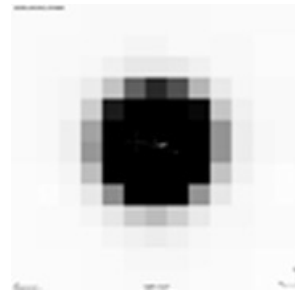


Figure 7: TDS5052  
1.9" PA 255



Figure 8: TDS3586  
2.2" PA 128

And one TDS object where there was uncertainty between the new image and the 2MASS images: TDS403. Tycho lists 1.5", PA 130, mags 10.39 and 11.69.



Figure 9: TDS403 2MASS J



Image 10: TDS403 2MASS K

## Measurements of some Tycho Double Stars – Follow Up Canis Minor and Columba

(Continued from page 547)

were always examined, and sometimes H-band as well. The conclusions given are from comparing the Tycho Position Angle and Separation with the images, within the limits of resolution possible from 2MASS.

### Summary

Overall in most cases the measurement results based on own images are well confirmed by the impressions based on 2MASS Sky Survey images and vice versa: 6 confirmations out of 26 objects, a non-conclusive result for TDS403, a small probability for TDS4547 not being bogus but simply wrong in separation and 18 most probably bogus.

The results obtained here, and in our previous paper, raise questions as to the reliability of the methodology and algorithms used for the much enlarged second version of the Tycho Double Star Catalogue. If only a minority of objects prove to be double, or even if many of them are double but do not fit the published measures, we have a significant problem of analytic methodology on the part of the catalogue creators. And if the same or similar methodologies are to be used for interpreting Gaia data, this will create huge problems of confirmation as many of the Gaia objects will not be accessible by other means.

We intend to produce future papers like this one. Increasing the survey of TDS/TDT objects should improve the statistical base and be of help for analytical treatment of possible patterns in the errors. The limitation the present authors have is inadequate equipment for studying the large number of Tycho objects with less than about 1.5" claimed separation. An attempt will be made to rectify that. But, in the meantime, it should be a matter of concern that a high proportion of the wider objects in the TDS/TDT catalogue appear to be bogus. These are objects well within the assessed capability of the system used. Most Tycho doubles have closer listed separations than we can access, and many of them are closer than the original assessed capability of Tycho, which suggests that the proportion of bogus objects could be even larger among the closer listings.

### Potential Further Research

Besides continuing to observe and image TDS objects wide enough to be resolved with the given equipment it might be of interest to image also rather close pairs for measurement of the combined magnitude and to compare this value with the calculated combined magnitude based on the current WDS catalog data – crass differences here should indicate questionable objects.

### 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 iT27: 700mm CDK with 4531mm focal length. CCD: FLI PL09000. Resolution 0.53 arcsec/pixel. V-filter. Located in Siding Spring, Australia. Elevation 1122m
- 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 and for high precision plate solving
- Tycho Double Star catalog for counterchecks
- 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 v4.8.2.405 for astrometry and photometry measurements

### References

- R. Buchheim, 2008, "CCD Double-Star Measurements at Altira Observatory in 2007", *Journal of Double Star Observations*, **4**, 28-32.
- C. Fabricius, E. Høg, V.V. Makarov, B.D. Mason, G.L. Wycoff and S.E. Urban, 2002, "The Tycho Double Star Catalogue", *Astronomy & Astrophysics*, **384**, 180-189.
- Knapp, Wilfried; Gould, Ross, 2016, "Visual Observation and Measurements of some Tycho Double Stars", *Journal of Double Star Observations*, **12**, 427-436.

# A New Double Star Observed During Lunar Occultation: TYC 6312-00761-1

Dave Gault (DG)

Kuriwa Observatory; Hawkesbury Heights; Australia  
 Email: [davegault@bigpond.com](mailto:davegault@bigpond.com)  
 Western Sydney Amateur Astronomy Group (WSAAG)  
 International Occultation Timing Association (IOTA)

Dave Herald (DH)

Murrumbateman; Australia  
 Email: [drherald@bigpond.com](mailto:drherald@bigpond.com)  
 Canberra Astronomical Society (CAS)  
 International Occultation Timing Association (IOTA)

**Abstract:** A lunar occultation observation by DG in March 2013 detected a new, previously unknown companion of star TYC 6312-00761-1. Subsequent lunar occultation observation by DH in September 2015 confirms the double star nature and the two observations when combined gives the solution;  $\text{Sep} = 0.527''$ ,  $\text{PA} = 131.59$  degrees, at a Mean Date of 2014.45.

## TYC 6312-00761-1

On 2013 March 7th, a lunar occultation reappearance of TYC 6312-00761-1 was video-recorded at 25 frames/sec by Dave Gault using a 30cm telescope. The waning moon was 19% illuminated. The light curve in Figure 1 was recorded.

The intermediate step lasted for 1.96 seconds, with the brighter star reappearing first. The position angle of the event on the moon's limb was  $327^\circ$  and the radial velocity of the moon at the location of the occultation was  $0.1851''/\text{second}$ . The observed magnitudes are 10.8 and 11.7.

On 2015 September 23rd, a lunar occultation disappearance of TYC 6312-00761-1 was video-recorded at 25 frames/sec by Dave Herald using a 40cm telescope. The waxing moon was 71% illuminated. The light curve in Figure 2 was recorded.

The intermediate step lasted for 0.96 seconds, with the brighter star disappearing first. The position angle of the event on the moon's limb was  $80^\circ$  and the radial velocity of the moon at the location of the occultation was  $0.3824''/\text{second}$ . The observed magnitudes are 10.7 and 12.0.

From the heights of the three portions of the two light curves the V magnitudes of the components are

derived as 10.7 and 11.8.

Star	TYC 6312-00761-1 = PPM 721083 = XZ 46854
Coordinates (J2000)	19h46m50.4935s, - 15°55'16.184"
Spectral type	F4
Derived double data:	
Mag A	$10.7 \pm 0.1$ (V)
Mag B	$11.8 \pm 0.1$ (V)
Epoch	2014.45 (average)
Separation at epoch	$0.527'' \pm 0.002''$
PA at epoch	$131.59 \pm 0.01$ deg

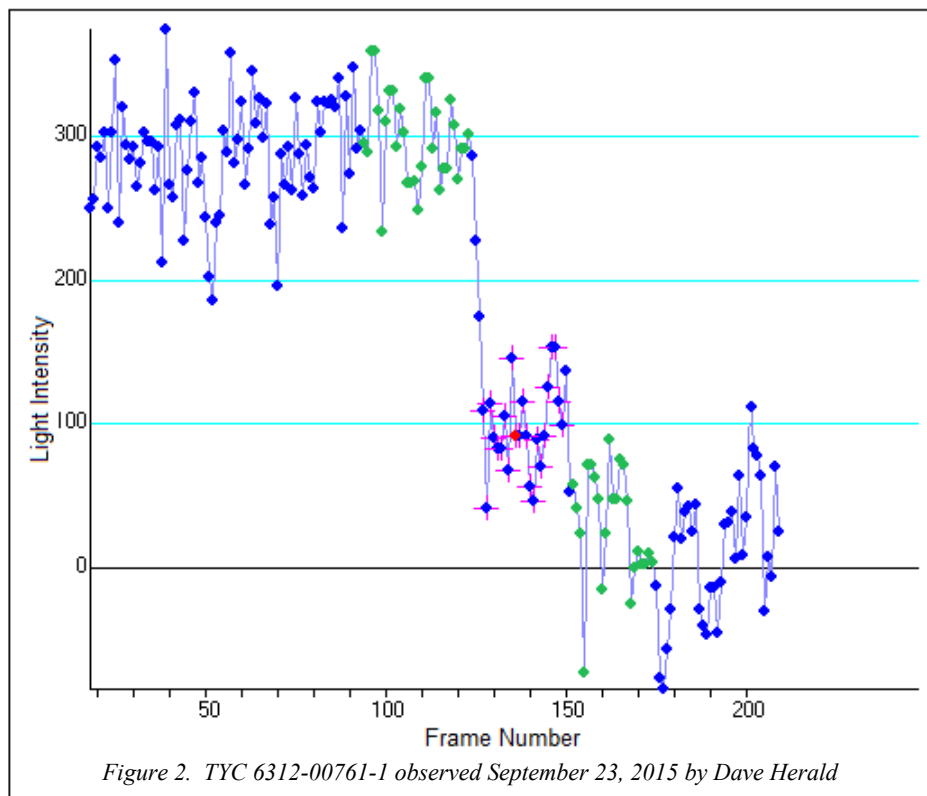
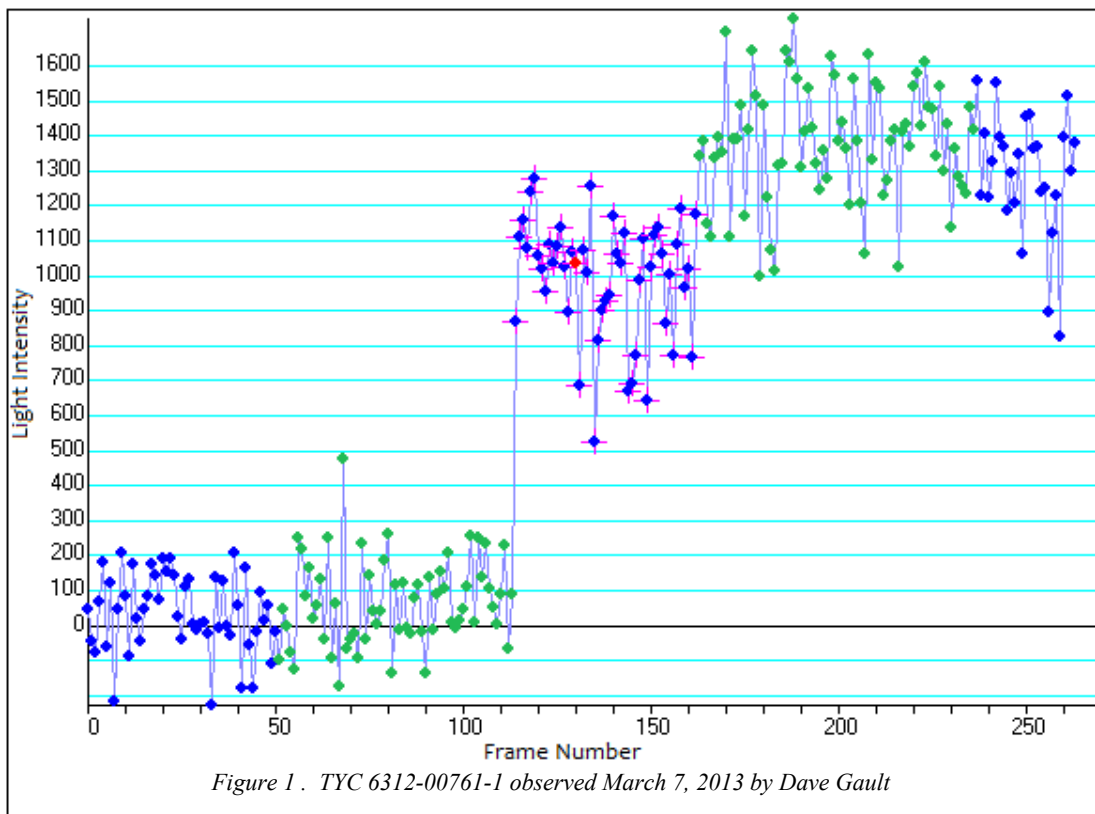
## Acknowledgement and Reference

Miyashita, K. : *Limovie* - [http://astro-limovie.info/limovie/limovie\\_en.html](http://astro-limovie.info/limovie/limovie_en.html)

Herald, D. : *Occult4* - <http://www.lunar-occultations.com/iota/occult4.htm>

Lunar Occultation Archive: VizieR Catalogue number VI/132A

### A New Double Star Observed During Lunar Occultation: TYC 6312-00761-1



# CCD Astrometric Measurements of WDS 08167+4053 Using the iTelescope Network

Bill Riley<sup>1</sup>, Dewei Li<sup>2</sup>, Junyao Li<sup>2</sup>, Aren Dennis<sup>2</sup>, Grady Boyce<sup>3</sup> and Pat Boyce<sup>3</sup>.

1. Cuesta College

2. Army and Navy Academy, Carlsbad, California

3. Boyce Research Initiatives and Education Foundation

**Abstract:** Separations and position angle astrometric measurements were made of the multiple star system WDS 08167+4053 AB, AC, and BC components. Our measurements compared favorably with historical measurements from the United States Naval Observatory Washington Double Star Catalog, confirming the trend.

## Introduction

Our study was conducted as part of an Astronomy Research Seminar offered by Cuesta College, supported by the Institute for Student Astronomical Research (InStAR), and conducted by Boyce Research Initiatives and Education Foundation (BRIEF) at the Army and Navy Academy (ANA) in Carlsbad, California. ANA is a college preparatory Middle and High School with a military structure focused on personal growth and leadership. Our team is shown in Figure 1.

The selection criteria for observations were double stars having a maximum magnitude difference of four between the stars, angular separation greater than seven arc seconds, presently observable in the night sky, and lacking recent reported observations. Limiting the

magnitude difference allowed the candidates to be clearly separated without stars of brighter magnitudes becoming overexposed during CCD imaging. Separations above seven arc-seconds ensure that the separate stars can be resolved on the CCD chip given the instruments used for this project.

WDS 08167+4053 matched the candidate criteria. This multiple star system lacks recent measurements, has a separation greater than 7.0 arc-seconds, and component magnitudes of 9, 9.9 and 10.1 for A, B and C stars respectively. Additionally, this system contains more than three published observations, allowing a comparison between the measurements of this paper against the historical values. Figure 2 shows WDS 08167+4053 in Mira Pro typical measurement of an AB pair.

## Equipment and Procedures

CCD measurements were completed using telescope T7 from the iTelescope network. T7 is a



Figure 1. Team Nail - Left to right: Dewei Li, Junyao Li, Aren Dennis, and Bill Riley



Figure 2: WDS 08167+4053 with AB pair marked in Mira Pro x64.

## CCD Astrometric Measurements of WDS 08167+4053 Using the iTelescope Network

Planewave 17" CDK located in Nerpio, Spain at an elevation of 5413 feet. Images were taken on two different nights, with luminance and Ha filters, and three different exposure times. Telescope T7 and CCD camera specifications are shown in Figure 3.

Images were acquired at epochs 2015.775 and 2015.795 with exposures of 60, 120, and 240 seconds using Ha and luminance filters for a total of thirty-two images. Several of the images, seen in Figure 4, were discarded due to diffraction spikes and fused centroids that were producing significant variances in position angle and erroneous centroids throughout several attempts to obtain accurate data from those images.

The remaining images were preprocessed (dark and flat subtraction) by iTelescope and then downloaded for analysis. MaximDL v6 was used to insert World Coordinate System (WCS) positions into the FITS headers through comparison of the image star field against the Fourth U.S. Naval Observatory CCD Astrograph Catalogue (UCAC4). During this process, MaximDL typically used approximately 180 stars out of a database of 790 stars for this particular star field.

Mirametrics Mira Pro x64 was used to locate accurate position angles and separations of the component stars. The A, B, and C stars were identified, marked, and then measured for position angle and separation through the algorithms of Mira Pro which are capable of locating the centroid of each star. Each stellar centroid RA and Dec, calculated position angle, and angular separation between the stars were recorded and entered into Microsoft Excel to calculate the standard deviation and standard error of mean from the astrometric results.

### Results

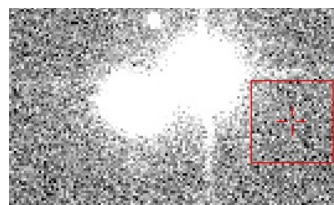
Table 1 shows the average of the measurements, the standard deviation, and the standard error of the mean for separation in arc seconds and position angles in degrees of the AB, AC, and BC pairs of WDS



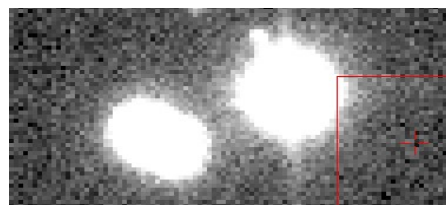
**Figure 3.** -iTelescope Platform used in the Boyce Astro Binary Star Research Seminar.

*Optical Design: Corrected Dall-Kirkham Astrograph*  
*Aperture: 431mm*  
*Focal Length: 2929mm*  
*F/Ratio: f/6.8*  
*Mount: Paramount PME*

*Instrument Package*  
*CCD: SBIG STL-11000M*  
*Anti-Blooming Gate (ABG)*  
*Resolution: 0.63 arc-secs/pixel*  
*Array: 4008 by 2672 (10.7 Mega pixels)*  
*FOV: 28.2 x 42.3 arc-mins*  
*Observatory: Nerpio, Spain*



Diffraction spiking  
Luminance filter  
120 second exposure



BC pair fused  
Luminance 120 second exposure

**Figure 4.** Typical examples of images with no measurement used.

**CCD Astrometric Measurements of WDS 08167+4053 Using the iTelescope Network**

*Table 1. Mira Pro measurement of the pairs of WDS 08167+4053.*

WDS 08167+4053				
Pair	Observations used		Position Angle (degrees)	Separation (arc seconds)
		Mean	344.6	20.8
AB	19	Standard Deviation	0.36	0.02
		Std. Error of Mean	0.083	0.005
		Mean	333.8	17.8
AC	25	Standard Deviation	0.82	0.10
		Std. Error of Mean	0.164	0.02
		Mean	209.7	4.74
BC	19	Standard Deviation	0.32	0.03
		Std. Error of Mean	0.073	0.069

*Table 2. Table of Historical data from the WDS catalog indicating WDS First and Last measurements compared to our 2015 measurements*

WDS Number	Pair	WDS	Observation Epoch		Position Angle deg.			Separation arc-sec			
			Hist.	WDS Historical		WDS Historical		New	WDS Historical		New
				First	Last	First	Last	2015	First	Last	2015
WDS 08167+4053	AB	20	1957.19	2010.265	249.6	343.8	344.7	20.4	20.88	20.8	
	AC	12	1969.052	1998.28	327.12	331.1	333.8	17.912	17.98	17.8	
	BC	19	1894.31	1998.28	210	209.9	209.9	4.419	4.8	4.75	

08167+4053. The comparison between these measurements and the published measurements in the WDS are found in Table 2.

**Discussion**

Several CCD images, and their respective measurements, were dropped due to the saturation and diffraction flaws described above. Fusing of stellar centroids in a CCD image occurs when adjacent stars are too close together on the CCD imaging chip, allowing the light from each star to blend preventing an accurate location of each independent stellar centroid. Such a situation is common in stars with small separations. In imaging this binary star system, the BC pair had a separation of only 4 arc seconds. This resulted in the blending of the two star’s centroids, and thus inaccurate measurements. Review of the WDS historical data, Table 3, raised questions surrounding the historical

measurements of two observations (epoch 1957 and epoch 1983) with regard to the position angle. These points might require further investigation as they are several standard deviations from the mean. The mean for the data group is 341 degrees and the standard deviation is 2.11 degrees.

Microsoft Excel was used to develop a scatter plot of the XY coordinate position of each pair. The results are shown in Figures 5 and 6. The measurements from this activity are indicated by an amber hexagon.

**Conclusion**

Our observed data was consistent with that of the USNO WDS Catalog published measurements showing consistency and a continuation of the historical trend.

*(Continued on page 562)*

CCD Astrometric Measurements of WDS 08167+4053 Using the iTelescope Network

**Table 3.** Historical data AB pair. The two position angles appear questionable.

Epoch	Position Angle	Separation	Note
1957.19	249.6	20.4	*PA differs by 89.04°
1969.051	338.64	20.454	
1973.137	339.137	20.534	
1974.047	339.198	20.474	
1982.041	339.911	20.387	
1982.937	339.733	20.378	
1983.44	335.5	19.224	
1984.216	340.292	20.452	
1987.14	340.403	20.382	
1987.263	341.8	20.47	
1987.263	341.3	20.54	
1989.938	341.161	20.534	

\*Measured with a Micrometer possibly accounting for the ~90 difference in measurement trends.

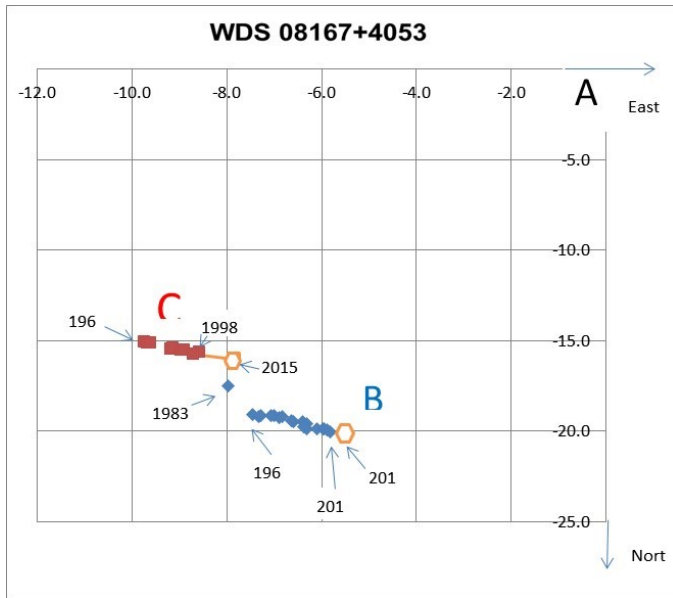


Figure 5. XY plot of AB and AC pairs historical position. Our data is shown with a hexagon. Squares indicate component C and diamonds indicate component B. Questionable point at Epoch 1957 was removed.

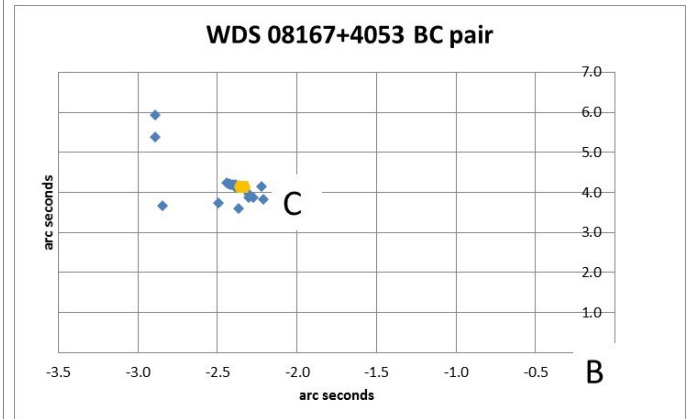


Figure 6. XY plot of BC pair historical position. Our data is shown with an amber hexagon.

## CCD Astrometric Measurements of WDS 08167+4053 Using the iTelescope Network

(Continued from page 560)

### Acknowledgements

The authors thank the United States Naval Observatory for providing historical measurement data and iTelescope for the use of their service. Additionally, we thank the Boyce Research Initiatives and Education Foundation (B.R.I.E.F.) for their generous financial donation that allowed us to use the iTelescope robotic telescope system and their proprietary software. We thank Mirametries for providing access to Mira Pro x64 for accurate astrometric measurements of our binary star system. The authors thank Russ Genet for providing guidance.

### References

- Frey, Thomas G, Johnson, Jolyon, Almich, Christopher J., and Genet, Russell M., 2010, "Visual Double Star Measurements with Equatorial and Alt-Azimuth Telescopes", *Small Telescopes and Astronomical Research*, Russell M. Genet, Jolyon M. Johnson, and Vera Wallen, eds. Collins Foundation Press, Santa Margarita, California.
- Genet, R.M., Johnson, J.M., and Wallen, V., 2010, *Small Telescopes and Astronomical Research*, Russell M. Genet, Jolyon M. Johnson, and Vera Wallen, eds. Collins Foundation Press, Santa Margarita, California.
- Mason, B. and Hartkopf, W. The Washington Double Star Catalog, October 2015. Astrometry Department, U.S. Naval Observatory. <http://ad.usno.navy.mil/wds/wds.html>. Department, U.S. Naval Observatory. <http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/ucac>.
- .



# Observations of Omicron 1 Cygni (STFA 50AD)

Jeff Bidler<sup>1</sup>, Joshua Hagee<sup>2</sup>, Paul McGuire<sup>2</sup>, Rosa McGuire<sup>3</sup>, Leslie Montes<sup>4</sup>,  
Nicole Richardson<sup>1</sup>, Arturo Rodriguez<sup>4</sup>, and Mark Brewer<sup>5</sup>

1. Fullerton College

2. Victor Valley Young Marines

3. University of California, Riverside

4. Victor Valley College

5. California State University, San Bernardino

**Abstract:** In over 215 years, the star STFA 50AD located in the Cygnus constellation has only been analyzed about 35 times. A group of eight individuals from five affiliations participated in the third annual Apple Valley Double Star Workshop to measure the separations and position angles of a double star. During this workshop, data from several astronomical identifiers was used to compare the data collected. The main apparatus used was an 8-inch telescope. An astrometric eyepiece and a stopwatch were used. The scale constant 9.9 arc seconds per division mark, separations 340.9 arc seconds, and position angles 324.1 degrees were determined by the telescope-eyepiece combination. The plate scale 1.01 arc seconds per pixel, separation 337.1 arc seconds, and position angle 321.3 degrees were determined by using the Digitized Sky Survey and Astrometrica. The results obtained were compared to previous observations listed in the Washington Double Star Catalog. After rigorous calculations and teamwork, it was concluded that the 2008 results were determined to be an outlier.

## Introduction

A three-day double star workshop was held by the High Desert Astronomical Society (HiDAS) and the Central Coast Astronomical Society (CCAS) to measure and report on the double star system Omicron 1 Cygni (STFA 50AD). The observations were made at the Thunderbird campus of the Lewis Center for Educational Research in Apple Valley, California, by a team of students from Fullerton College, Victory Valley Young Marines, University of California, Riverside, Victor Valley College, and California State University, San Bernardino. A group photograph of the observing team is shown in Figure 1.

The star system STFA 50AD is identified in the Washington Double Star Catalog (WDS) as 20136+4644, located at right ascension 20 hours 13 minutes 38 seconds and declination +46 degrees 44 minutes. The magnitudes of the primary and secondary



Figure 1. A group photo of the team. In the background from left to right: Paul McGuire, Nicole Richardson, Jeff Bidler, and Arturo Rodriguez. In the foreground from left to right: Rosa McGuire, Mark Brewer, Leslie Montes, and Joshua Hagee.

## Observations of Omicron 1 Cygni (STFA 50AD)



Figure 2: An image of the double star system STFA 50AD from the Digitized Sky Survey (DSS). The image was captured September 11, 1990 at 4:32:00 U.T.

stars are listed as 3.93 and 4.83. Figure 2 is a DSS image of this system. We compared our observations to early 19th century and 20th century observations, as well as the most recent observations listed in the WDS.

The WDS and the Set of Identifications, Measurements, and Bibliography for Astronomical Data (SIMBAD) were used to find different identifiers, including HD 192577, HIP 99675, and SAO 49337.

### Equipment and Procedures

A Meade 8-inch Schmidt Cassegrain telescope on a Celestron German equatorial mount equipped with a Celestron 12.5 mm Micro Guide astrometric eyepiece and a stopwatch that reads to the nearest thousandth of a second were used.

A drift method was used to calibrate and determine the scale constant of the telescope-eyepiece combination. The drift method was conducted by disabling the drive motor and timing the primary star's drift along the linear scale. A total of ten drift measurements were recorded. The scale constant was determined by the following equation:

$$Z = \frac{15.0411(T_{avg})\cos(dec)}{D}$$

where,  $Z$  equals the scale constant in arc seconds per division marks, 15.0411 equals Earth's rotational rate in arc seconds per second,  $T_{avg}$  equals the average drift time in seconds,  $\cos(dec)$  equals the cosine of the primary star's declination, and  $D$  equals the total displacement of the linear scale.

The separation was determined by aligning both stars along the linear. The division marks between the objects were recorded. Ten measurements were recorded and an average was determined. To determine the separation in arc seconds, the average separation in division marks was multiplied by the scale constant. The average, standard deviation, and standard mean of error were calculated for 6 trials.

The position angle was determined by aligning both stars along the linear, with the primary star on the 30th division, which marks the precise center of the eyepiece. The clock-drive was then disengaged, allowing both stars to drift to the inner protractor ring of the eyepiece. When the primary star reached the inner protractor ring, the clock-drive was reengaged and the primary star's position was estimated to the nearest degree. The average, standard deviation, and standard mean of error were calculated for 10 trials.

The Palomar Digitized Sky Survey and Astrometrica were used. The plate scale, separation, and position angle of the double stars were determined. The plate scale was determined by the following equation:

$$Z = \frac{206264.806(\text{pixel\_size})}{\text{focal\_length}}$$

where  $Z$  equals the plate scale in arc seconds per pixel, 206264.806 equals the factor of arc second in a radian, the pixel size is the size of one pixel in microns, and the focal length equals the distance that a photon travels through the telescope to the sensor.

The separation was determined using the following equation and multiplying the plate scale:

$$C = \sqrt{\Delta x^2 + \Delta y^2}$$

where  $C$  equals the total displacement in pixels,  $\Delta x$  equals the difference in the  $x$  axis, and  $\Delta y$  equals the difference in the  $y$  axis.

The position angle,  $\theta$ , was determined by the following equation:

$$\theta = \arctan\left(\frac{\Delta y}{\Delta x}\right)$$

### Observations and Analysis

Observations were made during the evening of June 17, 2015 (B2015.54082) in the west side parking lot of the Lewis Center for Educational Research in Apple Valley, California (N 34° 31' 58", W 117° 12' 48"). Observations took place during a phase of the Moon: Waxing Crescent with 3% of the Moon's visible disk illuminated according to the U.S. Naval Observatory Astro-

(Continued on page 565)

**Observations of Omicron 1 Cygni (STFA 50AD)**

*Table 1. Student Measurements*

	Units	# Obs.	Std. Dev.	Mean	Std. Mean Err.
<b>Drift Time</b>	seconds	10	1.0	57.5	0.3
<b>Separation</b>	arc seconds	6	0.5	340.9	0.2
<b>Position Angle</b>	degrees	10	1.1	324.1	0.34

nomical Applications Department, with fair sky conditions and a temperature of 78.8 degrees. Table 1 lists the averages (mean), standard deviations, and standard errors of the mean for the drift time, separation, and position angle measurements.

Table 2 lists the number of observations, the separation, and position angle measurements. Table 3 shows a comparison of the team’s data gathered from the eyepiece versus data listed in the WDS. The measurement on the position angle differs only by 0.3% compared to the data obtained during the observations compared to the 1800 and 2008 epochs. The position angle measurements compared to 2003 epoch differ by 0.4%. However, there is a difference in the measurements of separation of 0.9% with the data from 1800 and a 2.1% difference with the data obtained in 2008. The separation percentage differences compared to 2003 epoch differ by 1.2%. The large differences in the measurement of separation on 1800, 2003, and 2008 can be explained by the use of an astrometric eyepiece, a small telescope, and the total displacement of the double star on the eyepieces’ linear scale. The large displacement of the stars on the scale made the observer strain to be accurate to half to a full division mark.

Table 4 shows a comparison of the team’s data

*Table 2. Student Measurements*

	Units	# Obs.	Mean
<b>Separation</b>	arc seconds	1	337.1
<b>Position Angle</b>	degrees	1	321.3

gathered from the image of the Digitized Sky Survey versus the data listed in the WDS. The measurements of the position angle differ by 1.0% compared to the 1800 epoch, 0.4% to the 2003 epoch, and 1.0% to the 2008 epoch. The measurements of the separation differ by 0.3% compared to the 1800 epoch, 0.1% to the 2003 epoch, and 1.0% to the 2008 epoch. The percentage differences determined by the use of the Digitized Sky Survey’s image compare accurately to the three epochs listed in the WDS versus the differences of the astrometric eyepieces measurements.

Figures 3 and 4 show the comparison of the team’s separation and position angle measurements versus the 35 measurements listed in the WDS. The plots show the significant differences for the eyepiece measurements compared to the DSS image. The plots also show the DSS separation measurement compares favorably to the mean values, while the DSS position angle and eye-

*Table 3. Student Eyepiece Observations Compared to WDS Data*

Historical Observations			Comparison to Present Study			
Epoch	Position angle	Separation	Delta Position angle	Delta Separation	Percentage difference Position angle	Percentage difference Separation
1800	324.5	338.0	0.9	2.9	0.3	0.9
2003	322.7	336.7	1.4	4.2	0.4	1.2
2008	324.6	333.8	0.9	7.1	0.3	2.1

*Table 4. Student Digitized Sky Survey Observations Compared to WDS Data*

Epoch	Position angle	Separation	Delta Position angle	Delta Separation	Percentage difference Position angle	Percentage difference Separation
1800	324.5	338.0	-3.2	-0.9	1.0	0.3
2003	322.7	336.7	-1.4	0.4	0.4	0.1
2008	324.6	333.8	-3.3	3.3	1.0	1.0

Observations of Omicron 1 Cygni (STFA 50AD)

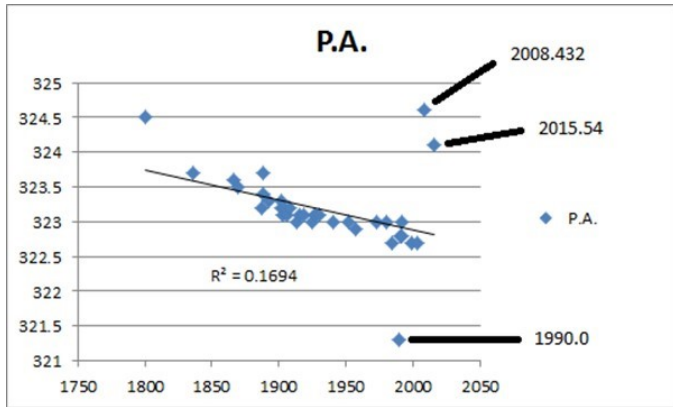


Figure 3. A graph of position angle measurements (35) listed in the WDS compared to the team's measurements 1990.0 and 2015.54

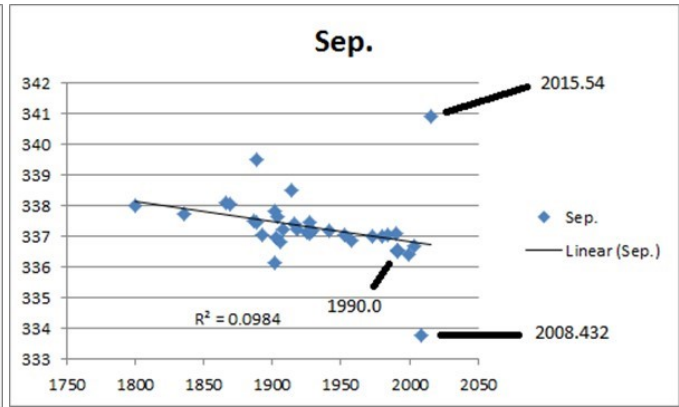


Figure 4. A graph of separation measurements (35) listed in the WDS compared to the team's measurements 1990.0 and 2015.54

piece separation and position angle measurements do not compare favorably.

**Conclusion**

At the end of the three day workshop, the team successfully measured the separations and position angles of the double star STFA 50AD with an astrometric eyepiece and an image from the Digitized Sky Survey. The team determined from the tables and plots that accurate measurements would only be acceptable to the Washington Double Star Catalog if digital images were gathered the nights of the event. The team did determine that the 2008 epoch listed in the WDS was an outlier compared to the mean values listed in the WDS.

**Acknowledgements**

This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory and the SIMBAD database, operated at CDS, Strasbourg, France. We would like to thank the Antelope Valley Astronomy Club, the High Desert Astronomical Society, the Central Coast Astronomical Society, the Victor Valley Young Marines, Walmart, and Starbucks for contributing to the success of the event.

**References**

Mason, Brian D. and Hartkopf, William I., 2013, United States Naval Observatory, Personal Correspondence.



# CCD Measurements of the Double Star STF 1744AB

Mark Brewer<sup>1,2</sup>, Gabriel Cacace<sup>3</sup>, Stacey Elderbaum<sup>2</sup>, Eryn Hernandez<sup>2,4</sup>, Celine Shay<sup>5</sup>,  
Mark Silva<sup>2</sup>

1. California State University, San Bernardino

2. High Desert Astronomical Society

3. Apple Valley High School

4. Victor Valley College

5. Academy for Academic Excellence

**Abstract:** Measurements of the double star STF 1744AB were conducted with an 8 inch telescope and a CCD camera was used. The plate scale was determined to be 0.8933 arc seconds per pixel. The software called Astroart was used to determine the separation and position angle, which were 14.9 arc seconds and 155.0 degrees. The Washington Double Star catalog was used as a comparison. Three goals were set: (1) understand the setup and operations of the telescope and the equipment used, (2) understand if the plate scale, separation, and position angle could be determined, (3) and observe, record, and report.

## Introduction

On July 26-27, 2014 measurements were gathered of the double star STF 1744AB. The observations were conducted at the Lewis Center for Educational Research's Thunderbird campus located in Apple Valley. An 8 inch Schmidt Cassegrain telescope on a CG5 German Equatorial mount equipped with a NEXIMAGE 5 CCD camera were used. Astroart 5.0 was used to determine the  $x$  and  $y$  coordinates of the primary and secondary stars. A plate scale equation was used to determine the plate scale of the telescope-camera combination in arc seconds per pixel. Two dimensional vector displacement equations were used to determine the separation and position angle in arc seconds and degrees. The Washington Double Star Catalog (WDS) lists the precise coordinates of the double star to be 132355.42+545531.5. Over 450 measurements have been documented in the WDS, with the first epoch of separation and position angle to be 13.9 arc seconds and 143 degrees. The last epoch lists the separation and position angle to be 14.5 arc seconds and 154 degrees respectively. The WDS lists the primary and secondary stars magnitude as 2.23 and 3.88. Figure 1 is a photograph of the observing team.

## Equipment and Procedures

An 8-inch Celestron Schmidt Cassegrain telescope with a focal length of 2032 millimeters was used. A Neximage 5 CCD camera was used (see Figures 2 and 3). The dimension of the CCD chip is 5700 by 4300



Figure 1. The authors from left to right: Mark Silva, Mark Brewer, Stacey Elderbaum, Eryn Hernandez, Celine Shay, and Gabriel Cacace.

microns with a pixel size of 8.8 by 8.8 microns with four times binning.

The following equation was used to determine the

$$Z = \frac{(206264.806)(0.0088)}{2032}$$

plate scale of the telescope-camera combination: where  $Z$  equals the plate scale in units of arc seconds

### CCD Measurements of the Double Star STF 1744AB



Figure 2. In the forefront is the author Mark Silva's 8 inch Celestron Schmidt Cassegrain telescope.

per pixel, 206264.806 equals one arc second per radian, 0.0088 equals the pixel size in units of millimeters, and 2032 equals the focal length of the telescope in units of millimeters.

The separation is given by

$$C = \sqrt{\Delta A^2 + \Delta B^2}$$

where  $C$  equals the separation in units of pixels,  $\Delta A$  equals the pixel difference of the stars on the  $x$  axis in units of pixels,  $\Delta B$  equals the pixel difference of the stars in the  $y$  axis in units of pixels.

The position angle is given by

$$\theta = \arctan\left(\frac{\Delta B}{\Delta A}\right)$$

where  $\theta$  equals the position angle in units of degrees.

#### Observations

Observations of the double star STF 1744AB were made on July 26, 2014 (B2014.568). A single frame bitmap image was captured of the double star. The exposure time was set to 0.1 second (see Figures 4 and 5). The plate scale was determined to be 0.8933 arc seconds per pixel. The separation was determined to be 14.8 arc seconds. The position angle was determined to be 155.0 degrees. A difference of -0.5 arc seconds and 1.0 degrees were determined by comparison of the last epoch listed in the Washington Double Star Catalog. The large difference in position angle was found to be the camera angle. A drift analysis should have been included to correct the camera angle.



Figure 3: An image of the NEXIMAGE 5 CCD camera

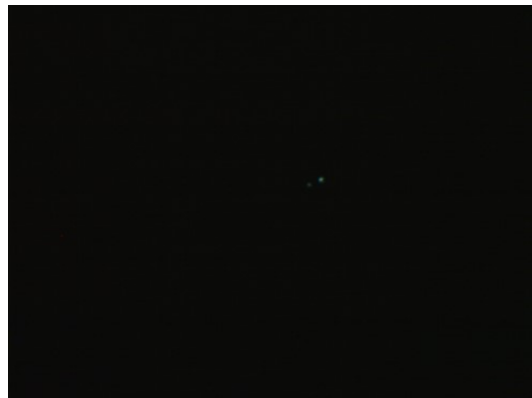


Figure 4. An image of STF 1744AB.



Figure 5. An enlarged image of Figure 4.

## CCD Measurements of the Double Star STF 1744AB

### Conclusion

The measurements gathered were not as accurate as hoped. The camera angle was not included in the observations, which skewed the measurements from determining a precise position angle. Had the drift analysis been done, the results would have compared favorably with the last epoch listed in the WDS. The goals set to understand the operations of the telescope and equipment were met, as well as the goals to determine the plate scale of the telescope-camera combination, separation, and position angle, and observe, record and report.

### Acknowledgements

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

Observatory. We would like to thank the external reviewers Joseph Carro, Vera Wallen, and Jo Johnson.

### References

Argyle, Robert W. *Observing and Measuring Visual Double Stars*. 2nd ed. London: Springer, 2012.

Mason, Brian. 2009. The Washington Double Star Catalog. Astrometry Department, U.S.

Naval Observatory. <http://ad.usno.navy.mil/wds/wds.html>



# Student Measurements of the Double Star Eta Cassiopeiae

Mark Brewer<sup>1,2</sup>, Gabriel Cacace<sup>3</sup>, Vivian Do<sup>3</sup>, Nicholas Griffith<sup>3</sup>, Alexandria Malan<sup>3</sup>, Hanna Paredes<sup>3</sup>, Brian Peticolas<sup>3</sup>, and Kathyne Stasiak<sup>3</sup>

1. California State University, San Bernardino

2. High Desert Astronomical Society

3. Vanguard Preparatory School

**Abstract:** The double star Eta Cassiopeiae was measured at Vanguard Preparatory School. Digital measurements were made with a 14-inch telescope equipped with a CCD camera. The plate scale was determined to be 0.50 arcseconds per pixel. The separations and position angles were determined to be 13.3 arcseconds and 340.4 degrees, by the use of astronomy software. Previous observations reported in the Washington Double Star Catalog were used as a comparison. The camera angle was found to be the ultimate issue in the skewed data gathered for the double star.

## Introduction

The Vanguard Double Star Workshop met on the dates of March 7 and 8, 2014. A Celestron 14-inch Schmidt Cassegrain telescope, a Santa Barbara Instrument Group (SBIG) ST8 CCD camera, and the vector components were used. The astronomy software Astrometrica for data reductions was used. Adjustments to the focus of the telescope-CCD camera combination were learned. The plate scale, separations, and position angles of the chosen double star were determined. Eta Cassiopeiae was chosen for its brightness, visibility in the night sky, and because it's a true double star. The importance of collimating a Schmidt Cassegrain telescope for digital measurements of a double star was learned.

Eta Cassiopeiae was first determined to be a double star by William Herschel in 1799. This double star consists of a primary star, Eta Cas  $\alpha$ , a yellow-orange star of magnitude 3.4, and Eta Cas  $\beta$ , an orange dwarf of magnitude 7.5. They are located about 19.4 light years from Earth. Eta Cassiopeiae can be found in the constellation of Cassiopeia. The Washington Double Star Catalog (WDS) lists the location and identifier of the double star at right ascension 004905.14+574859.4 and named STF 60AB. Over a thousand measurements have been reported in the WDS. The first epoch for separation and position angle was reported to be 11.3 arcseconds and 62 degrees, and the last epoch to be recorded was 13.3 arcseconds and 324 degrees.

The double star Eta Cassiopeiae can also be found in the online database called Set of Identifications, Measurements, and Bibliography for Astronomical Data (SIMBAD). The database lists multiple identifiers for the double star: SAO 21732, HIP 3821, HR 219, and USNO 793. SIMBAD offers plots and images of the

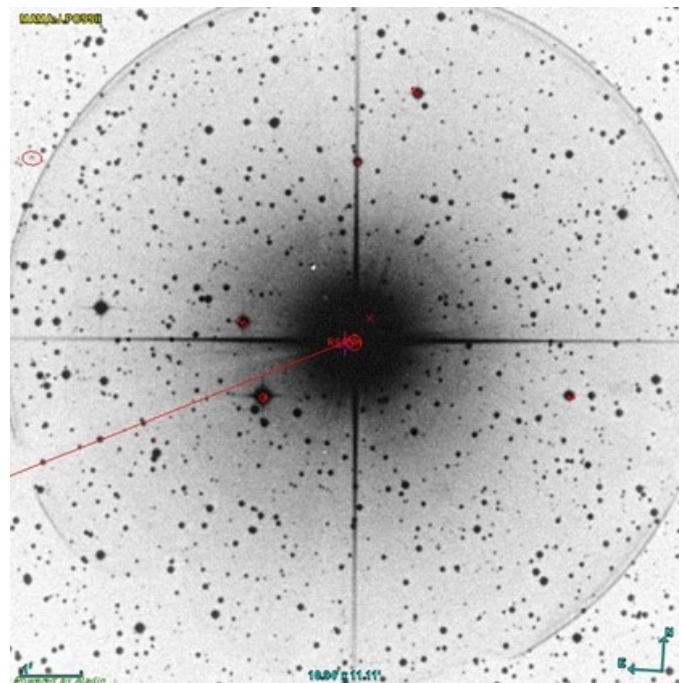


Figure 1: Field orientation for the double star Eta Cassiopeiae.

## Student Measurements of the Double Star Eta Cassiopeiae

double star with field orientation for precise astrometry. Figure 1 is an image from the Aladin Sky Atlas which was found through SIMBAD's database.

### Equipment and Procedure

A 14 inch Celestron Schmidt Cassegrain telescope on a fork mount equipped with a Santa Barbara Instrument Group (SBIG) ST8 CCD camera was used for capturing and analyzing the plate scale, separation, and position angle of the double star Eta Cassiopeiae.

The plate scale was determined by the following equation:

$$Z = \frac{(206264.806)(0.009)}{3910}$$

where 206264.806 is one radian in one arcsecond, 0.009 is the pixel size of one two-dimensional pixel in millimeters, and 3910 is the focal length in millimeters.

The separation was determined by the following equation:

$$c^2 = a^2 + b^2$$

where  $c^2$  is the separation in arcseconds,  $a^2$  is the difference in the x-axis squared, and  $b^2$  is the difference in the y-axis squared.

The position angle was determined by the following equation:

$$\tan \theta = \frac{b}{a}$$

where  $\theta$  is the position angle in degrees,  $b$  is the difference in the y axis, and  $a$  is the difference in the x axis.

### Observations

Observations and analysis were made on Friday, March, 7 and Saturday, March 8, 2014 (B2014.1799 and B2014.1825) in the small abandoned park of Vanguard Preparatory. Multiple images were gathered for precise measurements of the double star Eta Cassiopeiae. The centroid of the double stars was determined by tightening the focus of the double star for precise measurements. The astronomy software Astrometrica was used to locate the x and y values for the measurements of the separations and position angles. The team determined the plate scale of the telescope/CCD camera combination to be 0.50 arcseconds per pixel. The separations and position angles were determined to be 13.3 arcseconds, and 340.4 degrees. A comparison of the last epoch listed in the Washington Double Star Catalog was gathered. A difference of 0.1 arcseconds for separation and 17.4 degrees for position angle was deter-



Figure 2. Authors from left to right: Nicholas Griffith, Brian Peticolos, Vivian Do, Hanna Paredes, Alexandria Malan, Kathryne Stasiak, Gabriel Cacace, and Mark Brewer.

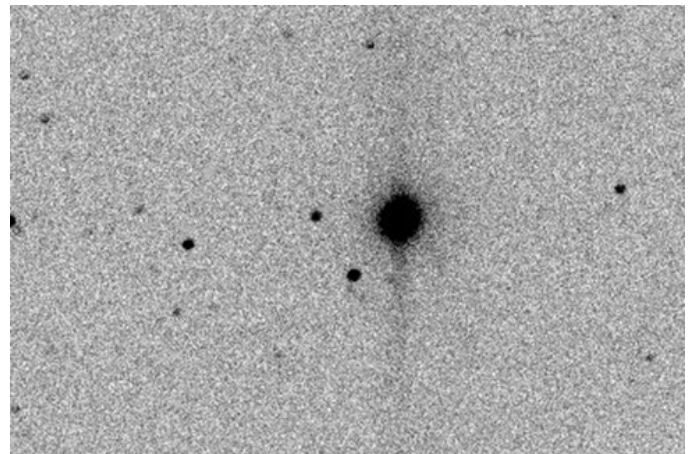


Figure 3: An image of the double star Eta Cassiopeiae.

mined. The large difference in position angle was due to not taking into account the camera angle not being zero degrees.

### Conclusions

The setup and operation of a Schmidt Cassegrain telescope with a CCD camera attached was learned. The importance of adjusting the focus, so the object was visually the smallest for pin-point accuracy was determined noteworthy. The plate scale, separations, and position angles measurements for comparison to the Washington Double Star Catalog were determined. The importance of calibrating the position angle of the camera, as it is very difficult to insert the camera such that its orientation is exactly north-south, was noted.

## Student Measurements of the Double Star Eta Cassiopeiae

The camera angle should have been determined by calibration measurements such as drifts either before or after the observations were made.

### Acknowledgments

This research made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory and the SIMBAD database operated at CDS, Strasbourg, France. We would like to thank the external reviewers Joseph Carro, Bob Buchheim, Jo Johnson, and Vera Wallen. We would like to thank Sean Gillette for executing a successful workshop. We would like to thank the Vanguard Preparatory School for the approval of the workshop. Lastly, we would like to thank the President of the High Desert Astronomical Society, Dave Meyer, for the loaned Celestron 14-inch Schmidt Cassegrain telescope and the Santa Barbara Instrument Group ST8 CCD camera.

### References.

- Argyle, Robert W. *Observing and Measuring Visual Double Stars*. 2nd ed. London, 2012.
- Springer, 2012. Mason, Brian. 2012. Washington Double Star Catalog. Astrometry Department, U.S. Naval Observatory. [ad.usno.navy.mil/wds/wds.htm](http://ad.usno.navy.mil/wds/wds.htm)
- Wenger *et al.*, "Set of Identifications, Measurements, and Bibliography for Astronomical Data", *A & AS*, **143**, 9, 2000.



## Appendix to Mind the Gap – Jonckheere Double Stars Not Listed in the WDS

John Nanson

Star Splitters Double Star Blog  
Manzanita, Oregon  
[jnanson@nehalem.tel.net](mailto:jnanson@nehalem.tel.net)

**Abstract:** This paper describes the results of efforts to identify fifty-two Jonckheere objects for which no data could be found in the WDS.

A previous paper, “Mind the Gap – Jonckheere Double Stars Not Listed in the WDS” (Nanson and Knapp, 2016), described an effort to determine the cross-referenced identifications of a large group of Robert Jonckheere’s double stars which failed to turn up in a search of the WDS catalog sorted by discoverer ID. During that process fifty-two Jonckheere objects were discovered for which no information or reference could be found, meaning they were entirely absent from both the WDS catalog and WDS Notes file.

To identify those objects, we turned to Jonckheere’s 1962 Double Star Catalog (*Catalogue Général de 3350 étoiles doubles de faible éclat observées de 1906 à 1962*) and looked at his entry for each of the fifty-two objects. We found fourteen of his catalog entries included references to previous observers, often with that observer’s designation included. That group of stars have now been incorporated into the WDS Notes file under the WDS identification assigned to the original observer’s designation (*Example: B 1953 [WDS 05569-1836] has this note: J 1469. Identified by Jonckheere as BOS 1953 in his 1962 catalog*). Those pairs have been coded green in Table 1.

Another group of twenty-seven which lacked that information were identified by plugging Jonckheere’s projected 2000 coordinates into Aladin (Jonckheere’s 1962 catalog lists coordinates for 2000, 1950, and 1900). These twenty-five objects were easily matched up with pairs which had been discovered by previous observers. (*Example: SEI 155 [WDS 05174+3500] has this note: J 184*). This group has been coded blue in Table 1.

In the process of matching Jonckheere’s projected 2000 coordinates into Aladin, we found five pairs that

could not be matched definitively based on Jonckheere’s measurements. We found possible or probable matches with previously discovered pairs for each of the five pairs. (*Example: HJ 3280 [WDS 05590+1321] has this note: Probably J 1916*). These pairs have been coded red in Table 1.

That left six objects to which Jonckheere assigned catalog numbers, none of which are double stars. Two of those are red stars, one is a nova, and three are galaxies. These have all been assigned a WDS identification number and entered into the WDS catalog with an “X” code, which designates the object as a “bogus binary”, and also entered into the WDS Notes file with a comment clarifying and identifying the object (*Examples: J 2001 [WDS 06556+0624] has this note: Variable CL Mon. Red star; and J 2501 [WDS 09200+0103] has this note: Radio galaxy UGC 4956*). These five objects are coded black in Table 1.

With the completion of this work, all 3350 Jonckheere objects are now accounted for in the WDS, either directly in the WDS catalog, or indirectly in the WDS Notes file through association with the designation assigned to a prior observer.

### Acknowledgements

Thanks to Wilfried Knapp, co-author on the Mind the Gaps Paper previously referred to, who provided the original impetus for this Jonckheere project. It would also be remiss at this point if we failed to mention the invaluable assistance provided by Bill Hartkopf for this endeavor. He supported the effort from the start and provided assistance along the way, as well as adding the updated information to the WDS.

The following tools and resources have been used

## Appendix to Mind the Gap – Jonckheere Double Stars Not Listed in the WDS

for this research:

- Aladin Sky Atlas v9.0
- SIMBAD, VizieR
- Sky Tools 3
- Stelle Doppie Web Site (<http://stelledoppie.goaction.it/>)
- Washington Double Star Catalog

### References

- Jonckheere, Robert, 1962. Catalogue Général de 3350 étoiles doubles de faible éclat observées de 1906 à 1962, Observatoire de Marseille and Journal des Observateurs, Place le Verrier, Marseille.
- Nanson, John; Knapp, Wilfried - 2016, Mind the Gap – Jonckheere Double Stars Not Listed in the WDS”, JDSO Vol. 12, No. XX, pp. xx-xx.

*Table 1. Green: Identified by Jonckheere with a prior discovery and/or designation. Blue: Obvious match with prior discovery. Red: Not a definite match. Black: Nebula, galaxy, or red star.*

Jonckheere Catalog Number	Right Ascension		Declination		1962 Catalog Page Number	Description
	H	M	D	M		
184	05	17.4	35	00	p. 55	SEI 155, WDS 05174+3500. Jonckheere includes an 1895 measure made by SEI, although its PA doesn't match the Obs1 PA in WDS.
810	18	55.7	12	55	p. 252	COG 1, WDS 18557+1254. A and C match the BD numbers cited by Jonckheere; COG is listed as an observer for AB, AC, and CD pairs.
1164	20	11.9	35	51	p. 321	SEI 983, WDS 20119+3551. Jonckheere's 1896 data for AB is a close match to WDS Obs1 data; his 1915 AC data is an exact match with WDS Obs1 data.
1169	20	17.5	32	00	p. 328	SEI 1065, WDS 20175+3205. Jonckheere's 1893 data matches Obs1 data in WDS; SEI listed by J as observer for his 1893 data.
1244	21	23.7	04	21	p. 367	STF 2791, WDS 21237+0422. Identified by Jonckheere as STF 2791 on p. 367 of his 1962 catalog. Cites Struve's 1827 data.
1382	19	20.2	00	56	p. 272	BAL 1202, WDS 19203+0056. BD and HD numbers cited by Jonckheere match up with BAL 1202; his 1895 data matches OBS 1 in WDS.
1445	01	25.2	-04	08	p. 29	HJ 638 (aka BU 1361), WDS 01252-0412
1468	05	16.5	-15	31	p. 55	GAL 172, WDS 05164-1531; identified by Jonckheere as HD 34390 and GAL 172 on p. 55 of 1962 catalog
1469	05	56.9	-18	35	p. 71	B 1953, WDS 05569-1836; identified by Jonckheere as BOS 1953 on p. 71 of 1962 catalog
1503	07	51.0	-24	14	p. 153	HDO 110, WDS 07510-2414. Jonckheere labels it as the CD pair of BU 1319 (HDO 110 CD), which he also includes in his data.
1511	08	15.0	-00	01	p. 161	J 72. Listed under J 72 (WDS 08149-0001) on p. 161 of 1962 catalog, where Jonckheere writes: "Aussi [also] J 1151."
1517	08	23.7	-21	36	p. 164	B 2654, WDS 08237-2137. The BD number cited by Jonckheere matches that of B 2654.
1599	19	00.8	-24	39	p. 256	COO 230, WDS 19010-2439. COO 230 matches the ADS number cited by Jonckheere; Cordoba is referenced in J's notes.
1600	19	07.5	-24	09	p. 261	B 426, WDS 19075-2407. Referred to as B 426 on p. 261 of Jonckheere's 1962 catalog. Also, J's ADS number matches up with B 426.
1628	18	22.4	-20	18	p. 225	BHA 27, WDS 18223-2018. The BD number cited by Jonckheere matches BHA 27.

*Table 1 continues on next page.*

## Appendix to Mind the Gap – Jonckheere Double Stars Not Listed in the WDS

Table 1 (continued). *Green: Identified by Jonckheere with a prior discovery and/or designation. Blue: Obvious match with prior discovery. Red: Not a definite match. Black: Nebula, galaxy, or red star.*

Jonckheere Catalog Number	Right Ascension		Declination		1962 Catalog Page Number	Description
	H	M	D	M		
1739	18	21.0	-17	15	p. 225	J 1627. Listed under J 1627 (WDS 18210-1714) on p. 225 of 1962 catalog, where Jonckheere notes "Aussi [also] J 1739".
1916	05	59.0	13	20	p. 72	Possible match with HJ 3280, WDS 05590+1321; proximity to BRT 1188 similar to Jonckheere's directions, PA not a good match, separation similar. (WDS Note File for HJ 3280 now reads "Probably J 1916").
2001	06	55.6	06	24	p. 120	Identified as a "red" star on pp. 120 and 318 of Jonckheere's 1962 catalog. Entered in the WDS as 06556+0624; Note File reads "Variable CL Mon. Red star."
2011	06	51.5	05	12	p. 115	Identified as a "red" star on pp. 115 and 318 of Jonckheere's 1962 catalog. Entered in the WDS as 06515+0512; Notes File reads "Variable CG Mon. Red star."
2023	06	33.1	12	27	p. 100	GCB 70, WDS 06333+1226. PA and separation match, as do Jonckheere's directions.
2066	08	53.4	-22	45	p. 171	DON 292, WDS 08535-2249. Identified as DON 292 on p. 171 of Jonckheere's 1962 catalog: "Aussi [Also] DON 292."
2301	08	11.8	-35	21	p. 160	Identified as "Nova Puppis" in Jonckheere's 1962 catalog, pp. 160 and 418. Entered in the WDS as 08118-3521; Note File for J 2301 reads "Nova Puppis = PK 252-00.1 = CP Pup."
2364	22	10.5	19	25	p. 380	BRT 2527, WDS 22104+1925. Identified as BRT 2527 on p. 380 of Jonckheere's 1962 catalog.
2371	22	32.0	28	47	p. 385	BRT 228, WDS 22320+2847. Probable match with BRT 228. Separation is close, PA of off by several degrees. WDS Notes File now reads "Probably J 2371."
2401	02	42.6	39	32	p. 37	WDS 02427+3932 : This is UGC 2180, which is identified as a nebula in Jonckheere's 1962 catalog, pp. 37 and 418. WDS Notes file now reads "Jonckheere says is two faint condensations of a nebula. Galaxy UGC 2180."
2436	06	46.6	04	37	p. 111	Possible match with UCAC4 473-023128 and 473-023127 . (This pair now identified as J 2436 with ID of WDS 06465+0435).
2437	06	46.7	13	05	p. 111	Possible match: J 2593, WDS 06468+1300. (WDS Note file for J2593 now includes "Probably J 2437").
2501	09	20.0	01	03	p. 176	Identified as a nebula in Jonckheere's 1962 catalog, pp. 176 and 418. Entered in the WDS as 09200+0103; Note File for J 2501 reads "Radio galaxy UGC 4956."
2557	19	44.0	-00	35	p. 294	RST 5142, WDS 19439-0034. BD number cited by Jonckheere matches that of RST 5142; J's 1943 data matches Obs1 data in WDS.
2585	18	54.0	15	15	p. 250	L 40, WDS 18540+1516. The BD number cited by Jonckheere matches L 40.
2589	06	02.7	00	14	p. 74	J 1362, WDS 06026+0014; note by Jonckheere on p. 74 of 1962 catalog: "Aussi [Also] J 1362."
2656	10	39.1	07	25	p. 184	J 1351 (WDS 10391+0726). Listed under J 1351 on p. 184 of Jonckheere's 1962 catalog.
2779	07	07.2	08	45	p. 130	J 3231, WDS 07077+0845. Date of discovery and PA match those of J 3231, separation is different by 1".
2794	07	15.0	09	56	p. 135	J 2457. Listed under J 2457 (WDS 07150+0956) on p. 135 of 1962 catalog, includes the note: "Aussi [also] J 2794."

Table 1 concludes on next page.

### Appendix to Mind the Gap – Jonckheere Double Stars Not Listed in the WDS

Table 1 (conclusion). *Green: Identified by Jonckheere with a prior discovery and/or designation. Blue: Obvious match with prior discovery. Red: Not a definite match. Black: Nebula, galaxy, or red star.*

Jonckheere Catalog Number	Right Ascension		Declination		1962 Catalog Page Number	Description
	H	M	D	M		
3001	13	38.5	-10	44	p. 196	PGC 48213. Identified as a nebula in Jonckheere's 1962 catalog, pp. 196 and 418; aka MCG -2-35-11. Not entered into the WDS Notes file at the time this paper was completed. Aladin shows J 2000 coordinates are 13h 38m 29.6s -10° 42' 16".
3216	19	39.5	41	38	p. 289	FOX 29, WDS 19395+4138. Jonckheere's AB and BC data are close matches with WDS data. BD +41 03441 is nearby per Jonckheere's notes.
3228	05	55.0	-07	00	p. 70	J 1915, which is also HJ 33, WDS 05569-0700; note by Jonckheere on p. 70 of 1962 catalog: "BC = J 3228."
3284	07	54.6	-00	08	p. 155	BAL 1121 (WDS 07545-0011); Jonckheere's 1893 data matches Obs1 data in WDS.
3306	05	14.0	39	57	p. 54	HU 1100, WDS 05139+3958 (Also cataloged as ES 280); Jonckheere's BD and HD designations match those of HU 1100
3333	02	00.2	-01	39	p. 33	BAL 9, WDS 02003-0138. Jonckheere's entry includes 1891 data, which matches WDS Obs1 data, and his BD designation also matches with BAL 9.
3334	04	09.3	-01	22	p. 44	BAL 290, WDS 04094-0125. Obs1 data almost an exact match with 1899 data shown by Jonckheere; also matches his BD designation.
3337	06	45.7	-05	20	p. 110	BRT 383, WDS 06456-0521. Jonckheere's BD number matches that of BRT 383, his 1894 data is almost an exact match with Obs1 data in WDS.
3339	07	09.7	10	09	p. 132	<b>Likely match: BRT 1223, WDS 07100+1008. Jonckheere's 1961 data is a close match to 2004 WDS data. (WDS Notes File for BRT 1223 now reads "Probably J 3339.")</b>
3341	18	04.9	03	11	p. 218	BAL 2471, WDS 18049+0311. Jonckheere's 1910 data are almost exact matches of WDS Obs1 data for 1910, magnitudes match.
3343	19	37.2	-16	09	p. 286	BRT 635, WDS 19371-1607. Jonckheere's 1905 data matches Obs1 in WDS.
3345	20	28.5	07	44	p. 336	BRT 2186, WDS 20284+0746. BD number cited by Jonckheere matches that of BRT 2186; his 1908 data is a close match to 1908 Obs1 data in WDS. The WDS Notes file for BRT 2186 now reads "AKA J 1299. J 3345. Damm match to J 1299 believed incorrect."
3347	20	44.8	20	32	p. 349	BRT 2484, WDS 20447+2032. Jonckheere's 1893 data is almost an exact match with WDS 1893 Obs1 data.
3348	21	13.5	-09	06	p. 363	BRT 515, WDS 21135-0905. Identified as BRT 515 on p. 363 of Jonckheere's 1962 catalog.
3349	21	49.5	-02	11	p. 375	BAL 266, WDS 21496-0208. Jonckheere's 1896 data is almost an exact match with WDS 1896 Obs1 data.
3350	22	17.2	17	25	p. 382	BRT 1358, WDS 22172+1725. BD number cited by Jonckheere matches that of BRT 1358.
3351	22	39.0	10	37	pp. 387-88	BRT 3369, WDS 22390+1037. Jonckheere's 1912 data matches WDS 1912 Obs1 data.
3352	22	42.9	11	00	p. 388	STF 2933, WDS 22428+1100. Jonckheere's BD designation matches that of STF 2933.

# CCD Measurements of Double Stars for 2015

Marcin Biskupski and Małgorzata Malinowska  
Polish Astronomy Amateur Association, division Szczecin, Poland  
[marcin.biskupski@ptma.szczecin.pl](mailto:marcin.biskupski@ptma.szczecin.pl)

**Abstract:** CCD imaging and measuring of double star systems was a part of an observational program held in the spring and summer of 2015 by a double star observing group from Szczecin, Poland (1). We report on 50 measurements of double stars made during this program.

## Introduction

The program was based on the observing list generated by Dr Brian Mason from the USNO<sup>2</sup>, previously requested by Biskupski. The list contained 54 stars with respect to the following specifications: RA from 13h to 18h; DEC from 15° to 60°; magnitudes < 10, no lower limit; separation: from 10" to 80"; last observations: 2005

Limits were mainly related with observatory location close to city center where visual measurements were carried out and telescope used - the Zeiss Coude-Refractor 150/2250 from year 1980. 20 of these stars was measured with reticle micrometer eyepiece<sup>1</sup>, others were imaged using itelescope.net network and measured via CCD methods with Astrometrica<sup>3</sup> and Reduc<sup>4</sup> software.

## Imaging

T18 (0.32-m f/8.0) from the Itelescope.net network was used for imaging the double star systems. Located in Nerpio (Spain) it allowed us to photograph almost all stars from the observational list. As the list was basically prepared for visual observations and the maximum magnitudes were only 10, times applied to images were short, from 1'' to 40'' (1x1 bin). Additionally, a photometric V filter was used on all images. The standard procedure was to make about 10 images of a system during a single night, then repeat this procedure on the

night after. Unfortunately, it was impossible to maintain this discipline due to a few factors like weather, system availability or moon position so there are "gaps" between observational nights that may be for days, weeks or, in extreme cases, months. All dates in Table 1 were averaged and are given in Besselian years.

## Method

Images from a single night were calibrated with Astrometrica<sup>3</sup> then measured in Reduc<sup>4</sup>. Aladin<sup>5</sup> was used to determine the location of the double stars and each component of the system. Errors contain standard deviations from single nights and calibration errors combined. If there were more data than images from one night then a weighted mean for theta and rho were used to define final errors.

## Results

Table 1 contains 50 measures of the stars from the observing list<sup>2</sup>, as well as other systems imaged by author and stars that appeared in the imaged field of view.

## Discussion on Unconfirmed Stars SLE 23 and DEA 53

SLE 23 and DEA 53 are double star systems with no confirmation, meaning that only one measurement is listed in WDS catalog<sup>2</sup>.

SLE 23 has a single measurement from 1982 with

*(Continued on page 579)*

## CCD Measurements of Double Stars for 2015

Table 1. Measurements

disc	wds	mags	theta	err	rho	err	date
STFA 46AB	19418+5032	6.00 6.23	133.12	0.02	39.75	0.05	2015.63064228
LDS1017	19072+2053	10.95 10.99	290.20	0.05	113.83	0.31	2015.61421482
STFA 35	17322+5511	4.87 4.90	311.03	0.59	62.38	0.51	2015.35685134
STF1627	12182-0357	6.55 6.90	194.83	0.04	20.16	0.01	2015.23638333
STF2486AB	19121+4951	6.54 6.67	203.36	0.55	7.17	0.21	2015.61695273
SMA 85	19127+4945	9.04 10.01	210.96	0.07	30.54	0.23	2015.61695273
KZA 41	13089+3800	10.87 14.34	19.70	0.04	30.42	0.02	2015.35685134
KZA 44AB	13104+3744	12.16 12.32	208.79	0.20	76.65	0.04	2015.35685134
KZA 44AC	13104+3745	12.16 11.27	4.52	0.24	93.24	0.29	2015.35685134
KZA 55AB	13221+4354	6.35 11.5	306.96	0.78	45.65	0.28	2015.35958925
KZA 55AC	13221+4355	6.37 11.96	58.72	0.35	67.61	0.38	2015.35958925
KZA 55AD	13221+4356	6.37 13.04	247.63	0.26	75.30	0.18	2015.35958925
KZA 71AB	13363+3514	11.23 12.78	147.75	0.25	62.55	0.06	2015.37327880
KZA 71AC	13363+3515	11.23 13.96	185.92	0.25	78.82	0.20	2015.37327880
SKF 10	15111+4424	10.24 10.90	279.35	0.02	12.78	0.01	2015.35685134
ARY 42	15174+3022	9.30 9.63	186.37	0.02	95.02	0.04	2015.42803698
BU 421AB,C	18517+4323	9.80 9.61	226.41	0.03	43.13	0.01	2015.57314618
BU 1249AB,C	17220+5351	9.36 9.83	77.79	0.02	62.10	0.09	2015.55671872
DEA 53	15391+4352	7.20 9.92	295.44	1.46	42.05	0.72	2015.48553308
ES 2655	16566+4505	9.72 9.92	67.14	0.10	47.47	0.08	2015.52112590
ES 2661AB	17374+5040	8.46 9.84	102.12	0.04	58.27	0.04	2015.54485445
ES 2661BC	17374+5041	9.84 12.8	17.60	0.15	14.92	0.07	2015.54485445
ES 2666	18259+6029	8.45 9.92	269.65	0.05	45.17	0.02	2015.53025227
GUI 16AC	16076+2900	7.93 9.48	350.37	0.04	118.06	0.05	2015.58888916
HJ 2828	18144+2127	9.23 9.84	109.71	0.03	16.35	0.01	2015.59322418
BIG 2	18142+2127	9.7 11.7	141.35	0.06	34.18	0.03	2015.59322418
H N 5AD	17246+3215	8.65 8.98	14.95	0.01	152.31	0.02	2015.62151591
H N 5AB	17246+3216	8.65 12.5	356.11	0.20	24.57	0.03	2015.62151591
H N 5AC	17246+3217	8.65 12.2	181.00	0.14	37.23	0.07	2015.62151591
LDS 995	17267+3105	8.48 9.67	199.76	0.01	67.78	0.01	2015.59596209
LDS1758	12485+8134	9.92 9.99	333.20	0.06	85.03	0.02	2015.52112590
S 648	13131+1801	9.35 9.97	68.99	0.16	88.17	0.38	2015.49100890
SCA9002AB	17103+5403	9.54 9.88	84.21	0.01	79.50	0.04	2015.58866100
STF 1691 AB	12550+5810	8.58 9.80	274.98	0.22	18.63	0.06	2015.52933963
STF 1691 AC	12550+5810	8.58 9.61	83.85	0.01	130.29	0.01	2015.52933963
STF 1920	15108+4651	9.92 9.98	109.22	0.19	18.70	0.04	2015.55033027
STF 1991 AC	15574+4140	9.45 8.82	87.39	0.01	94.95	0.07	2015.59048627
STF 2219	17413+6136	8.59 9.81	95.35	0.09	17.00	0.07	2015.61512746
STF 2323 BC	18239+5848	8.07 7.95	19.48	0.17	88.50	0.04	2015.57109275
WAL 150 AC	18384+6332	6.97 9.66	350.58	0.06	94.85	0.05	2015.60052528
STF 2377 AB	18384+6332	6.97 9.83	338.18	0.09	16.82	0.05	2015.60052528
WEI 33	18523+3926	8.96 8.99	329.50	0.01	99.97	0.03	2015.62334118
WFC 216	18551+1644	9.07 9.55	88.26	0.01	11.87	0.01	2015.61010796
STF 1976 AB	15449+5926	9.66 9.92	70.26	0.01	19.16	0.11	2015.54166022
STF 1976 AC	15449+5926	9.66 11.58	213.99	0.01	132.74	0.13	2015.54166022
SHJ 136	12110+8143	6.15 8.25	74.14	0.04	71.39	0.01	2015.56903932
HO 414 AC	17222+2605	9.43 12.78	303.61	0.02	30.82	0.08	2015.59687473
STF2416 AB	18521+5120	8.67 11.17	158.26	0.02	19.87	0.04	2015.60326318
STF2416 AC	18521+5121	8.67 9.41	40.21	0.05	121.58	0.01	2015.60326318
STT 316	16489+5930	7.79 8.93	348.01	0.10	47.10	0.08	2015.60600109

## CCD Measurements of Double Stars for 2015

(Continued from page 577)

position angle  $92^\circ$ , separation  $24.1''$ , and magnitudes of stars 9.43 and 9.8. Figure 1 shows that there is nothing as bright as 9.8 mag at the position listed in the 1982 measurement. There is another confirmed double star in this field HO 414 AC, which was identified and measured.

DEA 53, discovered in 1998 has following results: position angle  $295^\circ$ , separation  $42.1''$  and magnitudes 7.2 and 9.92 respectively. There is very weak source in given location of the B component (Figure 2) but magnitudes are not correct. Reduc measured  $\Delta M$  is 8.53 with a standard deviation of 0.4. It is clearly very far from the value given in the WDS (2). One of the possibilities is that the B component is a variable star. Further study is needed to determine its nature.

### Acknowledgements

Special thanks to Francisco Rica Romero for great patience and detailed help on ccd double star measurements. We would like to thank also Brian Mason for help with observing list.

### References

1. Biskupski, Marcin, et al., "Measurements with Reticule Micrometer Performed by a New Double Star Observing Group from Poland", *Journal of Double Star Observations*, **12**, 374-375, 2016.
2. Brian D. Mason, United States Naval Observatory, personal communication.
3. Raab, Herbert: Astrometrica. <http://www.astrometrica.at>
4. Losse F. Reduc software, <http://www.astrosurf.com/hfosaf/uk/tdownload.htm>
5. Aladin Sky Atlas: <http://aladin.u-strasbg.fr/>

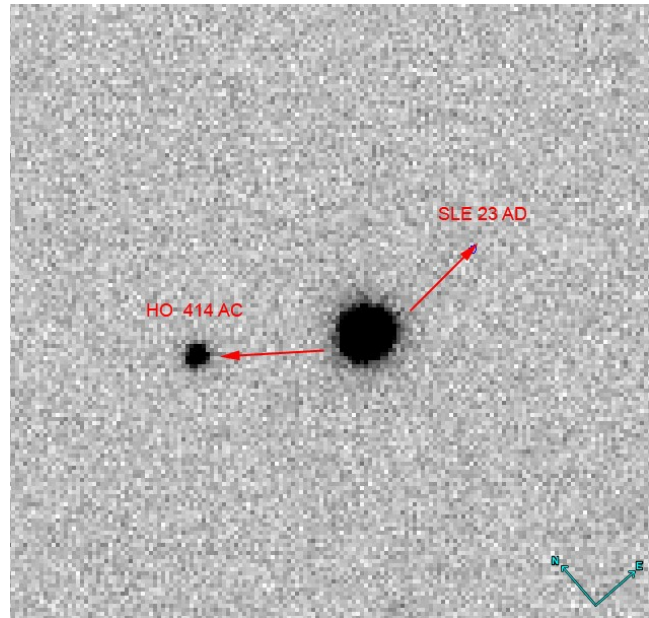


Figure 1. Image of SLE 23.

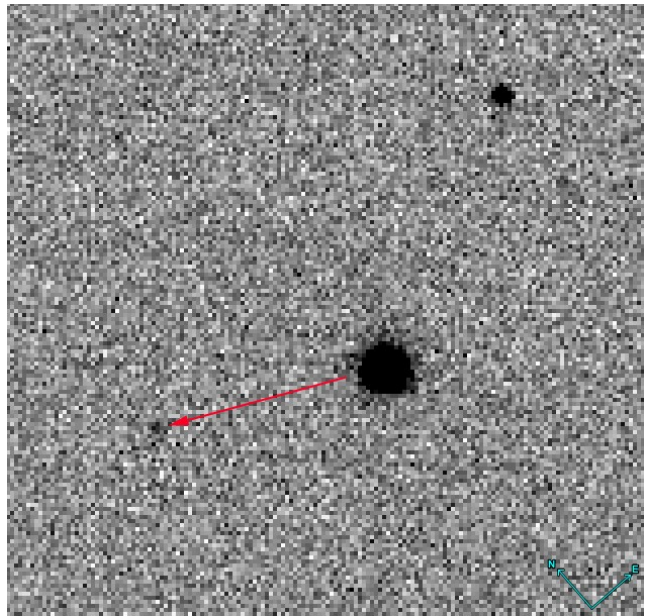


Figure 2. Image of DEA 53.

# Near IR Measures II, 9-12 hr and Reference Stars

George Gatewood and Carolyn Gatewood

Sirius Two Observatory  
665 Forest Pine Drive  
Ball Ground GA, 30107  
[Gatewood9@att.net](mailto:Gatewood9@att.net)  
<http://www.pitt.edu/~gatewood/>

**Abstract:** We list position angles, separations, and magnitude differences of our reference double stars and program double stars between 9<sup>hr</sup> and 12<sup>hr</sup> right ascension.

## Introduction

The facilities and procedures used in our retirement hobby have remained virtually the same as noted in the reference (Gatewood and Gatewood 2012). After some testing we now use the magnitudes differences derived by ASTROSURF's REDUC. And we also installed MaxPoint for telescope control. This has improved our "on target" time significantly, usually placing the field well within our finder's small CCD field and occasionally within the much smaller field of our main camera. To reduce our systematic error we have expanded our reference system to include 36 selected wide double stars. The general character of that system can be determined from their annual means listed in Table 1.

## Results

Even though we only observe a few good nights per year, we have obtain quite a bit of data. Much of it is better than we had thought possible from our north Georgia site. Table 1 lists the WDS number of each star followed by its discovery designation and the annual mean date of the observations. The position angles and separations with their standard errors are next followed by the average difference in the I band magnitude of the components and the number of nights observed in each listed year. Finally we list the total number of exposures in the mean. Unless given in the notes, the total number of delta I magnitude measurements is the same as the number of exposures. Where measured, V band and B band magnitudes and comments are given in the notes.

The standard errors listed in Table one are based upon the value given by the reduction program RE-

DUC, the number of exposures, and our estimate of the standard errors of the reference system. The derivation of the field scale of the system included an analysis of the previous observations of 36 wide double stars provided to us by the US Naval Observatory. The correction to the main camera's rotation angle was based on the fit of the data to 152 star trails acquired regularly during the several observing periods. A more detailed description is beyond the scope of the present paper and will be provided later.

Most of the double stars with right ascensions between 9 and 12 hours are regular program pairs, the exceptions are S598AB, STF1424CD and STF1579AB-D. These double stars are part of our reference system. Double stars outside of those limits are generally reference stars or their companions. STTA177AC was originally part of that system but the third star in the system, BU139AB, seemed to be the cause of higher measurement errors. GAT3AB was included so that we could point out an interesting progression in its position angles and also those of STTA177AC.

## Acknowledgements

Thanks to Brian Mason and William Hartkopf for for answering numerous data requests. This research made extensive use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory.

## References

Gatewood, G.D. and Gatewood, C.V. 2012, **8**, 4, 335-339.

## Near IR Measures II, 9-12hr and Reference Stars

Table 1. Measurements

WDS	NAME	DATE	PA	sePA	SEP	seSEP	Ia-b	N	exp
00097+5202	BU 484AC	2011.888	51.46	0.012	83.244	0.012	2.16	1	36
00097+5202	BU 484AC	2013.786	51.35	0.009	83.272	0.016	2.08	3	110
00097+5202	BU 484AC	2014.658	51.35	0.008	83.284	0.017	2.04	1	107
00097+5202	BU 484AC	2015.668	51.33	0.008	83.248	0.017	2.15	1	78
00097+5202	BU 484AB	2014.717	156.83	0.206	1.857	0.011	3.71	3	133
00097+5202	BU 484AB	2015.668	156.50	0.199	1.802	0.009	3.85	1	53
00464+3057	STFA 1AB	2013.776	46.47	0.021	47.338	0.024	0.15	3	92
00464+3057	STFA 1AB	2014.655	46.44	0.018	47.307	0.016	0.13	1	107
00464+3057	STFA 1AB	2015.718	46.41	0.010	47.311	0.012	0.12	1	90
01057+2128	STF 88AB	2011.923	159.24	0.036	29.711	0.017	0.41	1	23
01057+2128	STF 88AB	2013.805	159.24	0.024	29.731	0.018	0.28	3	123
01057+2128	STF 88AB	2014.655	159.27	0.021	29.729	0.013	0.25	1	118
01057+2128	STF 88AB	2015.956	159.27	0.023	29.748	0.017	0.19	1	53
01323+4559	BVD 18	2013.825	231.11	0.008	85.356	0.017	0.31	2	79
01323+4559	BVD 18	2014.658	231.08	0.008	85.354	0.016	0.30	1	127
01323+4559	BVD 18	2015.956	231.13	0.010	85.509	0.023	0.29	1	59
03092+0728	STFA 6	2013.860	163.22	0.009	80.892	0.018	0.20	1	67
03092+0728	STFA 6	2015.811	163.17	0.010	80.959	0.018	0.17	2	153
03494+2423	STTA 40AB	2011.978	309.12	0.012	86.925	0.020	0.81	2	43
03494+2423	STTA 40AB	2013.860	309.13	0.008	86.911	0.015	0.81	2	70
03494+2423	STTA 40AB	2015.668	309.09	0.008	86.872	0.014	0.83	1	86
04422+2257	S 455AB	2011.978	213.71	0.019	62.773	0.036	2.59	1	24
04422+2257	S 455AB	2013.863	213.67	0.010	62.806	0.015	2.68	1	74
04422+2257	S 455AB	2015.668	213.65	0.012	62.792	0.015	2.73	1	77
04590+1433	SHJ 49AB	2011.986	305.69	0.018	39.307	0.016	1.51	1	23
04590+1433	SHJ 49AB	2013.863	305.71	0.010	39.304	0.008	1.53	2	111
04590+1433	SHJ 49AB	2015.958	305.69	0.010	39.305	0.013	1.56	1	88
05308+3950	STTA 63	2011.926	276.74	0.018	76.063	0.024	1.12	1	44
05308+3950	STTA 63	2015.958	276.81	0.008	76.092	0.013	1.23	1	175
05479+2441	STTA 66	2012.082	166.27	0.026	93.877	0.059	0.75	1	13
05479+2441	STTA 66	2015.956	166.27	0.007	93.746	0.016	0.77	1	101
07006+1243	STF1007AD	2012.066	28.43	0.016	67.900	0.026	0.37	1	16
07006+1243	STF1007AD	2013.863	28.46	0.007	67.941	0.012	0.39	1	124
07006+1243	STF1007AD	2015.956	28.45	0.009	67.913	0.013	0.37	1	96
07510+3137	STTA 89	2012.071	83.60	0.018	76.753	0.024	0.85	1	27
07510+3137	STTA 89	2013.863	83.63	0.010	76.775	0.015	0.92	1	79
07510+3137	STTA 89	2015.956	83.64	0.007	76.792	0.012	0.93	1	211
08404+1940	STF1254AB	2013.863	54.55	0.013	20.524	0.005	4.35	2	89
08404+1940	STF1254AB	2014.264	54.54	0.025	20.531	0.009	4.22	2	182
08404+1940	STF1254AB	2015.956	54.49	0.010	20.517	0.004	4.32	2	369
08404+1940	STF1254AC	2013.863	342.81	0.007	63.370	0.011	2.03	2	89
08404+1940	STF1254AC	2014.263	342.80	0.008	63.377	0.013	2.06	2	217
08404+1940	STF1254AC	2015.956	342.78	0.007	63.358	0.010	2.02	2	371
08404+1940	STF1254AD	2013.863	44.01	0.007	82.636	0.014	3.44	2	89

Table 1 continues on next page.

## Near IR Measures II, 9-12hr and Reference Stars

Table 1 (continued). Measurements

WDS	NAME	DATE	PA	sePA	SEP	seSEP	Ia-b	N	exp	nt
08404+1940	STF1254AD	2014.263	44.02	0.009	82.642	0.015	3.42	2	217	
08404+1940	STF1254AD	2015.956	43.99	0.007	82.600	0.012	3.43	2	371	
08404+1940	S 572CD	2013.863	90.83	0.007	76.152	0.013	1.41	2	89	
08404+1940	S 572CD	2014.264	90.84	0.009	76.170	0.013	1.35	2	212	
08404+1940	S 572CD	2015.956	90.82	0.007	76.131	0.011	1.41	2	371	
09078-0013	SCJ 12	2012.255	261.25	0.174	6.566	0.022	0.00	1	25	3
09136+4659	STF1318	2012.285	228.46	0.165	2.600	0.014	1.32	1	30	4
09184+3522	STF1333	2012.285	49.85	0.190	1.910	0.008	0.26	1	26	5
09210+3811	STF1338AB	2012.266	305.40	0.402	1.067	0.011	0.22	1	13	
09233+0921	HEI 487	2012.203	104.80	0.407	1.069	0.013	1.66	1	28	6
09245+0621	STF1438AB	2012.285	314.12	0.358	1.978	0.016	0.03	1	9	
09273+0614	STF1355	2012.285	353.44	0.768	1.752	0.015	0.17	1	13	
09287+4536	S 598AB	2013.862	160.79	0.008	70.590	0.015	2.77	1	74	
09287+4536	S 598AB	2014.274	160.80	0.011	70.598	0.017	2.85	1	55	
09541+0457	S 605	2012.287	286.59	0.078	53.525	0.044	2.31	1	8	
10016+5535	KUI 46	2012.268	48.65	0.322	2.881	0.023	3.33	1	37	
Hip 49544	Gat 4	2015.342	211.93	0.762	2.359	0.053	2.36	1	28	7
10200+1950	STF1424CD	2013.863	4.79	0.012	90.623	0.024	2.35	1	16	
10200+1950	STF1424CD	2014.274	5.13	0.008	90.530	0.119	2.47	1	31	
10200+1950	STF1424AB	2012.257	126.25	0.070	4.700	0.006	1.38	1	48	
10347+4639	ES 918	2012.255	189.18	0.362	3.372	0.024	0.13	1	32	8
10432+3849	MLB 933	2012.266	245.11	0.319	3.631	0.016	1.09	1	28	
10470+1302	STF1472	2014.339	37.09	0.016	43.364	0.027	0.91	1	17	9
10598+5854	STF1495	2013.862	36.32	0.014	33.982	0.015	1.98	1	52	
10598+5854	STF1495	2014.348	36.37	0.020	34.007	0.018	1.88	1	41	
11046+1240	SIN 62	2012.285	round		Rho<0.6			1		10
11065+1416	HU 885AB	2012.219	257.14	0.568	1.985	0.018	0.93	1	5	
11065+1416	HU 885AB	2014.339	255.03	0.635	2.052	0.021	0.93	1	7	
11111+3027	STT 231AB	2014.300	262.55	0.012	34.155	0.007	1.11	2	94	
11129+3130	HEI 12	2012.285	122.06	1.302	2.346	0.057	0.77	1	20	11
11129+3130	HEI 12	2014.339	122.40	1.731	2.409	0.038	0.68	1	11	
11252+1608	HEI 156AB	2015.339	159.58	0.903	1.620	0.020	0.71	1	14	
11252+1608	UC 2134AC	2012.255	45.05	0.057	24.880	0.017	1.39	1	30	12
11252+1608	UC 2134AC	2015.339	45.05	0.053	24.968	0.016	1.54	1	53	
11263+1610	HEI 157	2015.339	156.61	1.143	1.602	0.023	0.93	1	12	
11279+0251	STFA 19AB	2013.862	181.63	0.038	88.463	0.082	2.85	1	10	
11279+0251	STFA 19AB	2014.265	181.70	0.015	88.764	0.024	2.97	1	22	
11323+3323	ES 2284	2012.285	76.72	1.098	3.007	0.035	0.83	1	13	13
11323+3323	ES 2284	2014.348	74.79	0.921	3.096	0.044	0.73	1	13	
11390+4109	STT 237AB	2012.329	244.44	0.102	2.045	0.004	0.90	2	67	
11406+2102	STF1566	2012.329	349.35	0.090	2.382	0.004	1.74	1	59	14
11456+0354	HJ 1196AB	2014.348	204.57	0.037	46.062	0.019	0.53	1	11	
11456+0354	HJ 1196AB	2015.339	204.65	0.029	46.391	0.025	0.69	1	53	
11456+0354	GAT 5Aa, Ab	2014.348	161.09	2.588	0.798	0.043	0.13	1	8	15

Table 1 continues on next page.

## Near IR Measures II, 9-12hr and Reference Stars

Table 1 (continued). Measurements

WDS	NAME	DATE	PA	sePA	SEP	seSEP	Ia-b	N	exp	nt
11456+0354	GAT 5Aa, Ab	2015.339	165.69	1.855	0.873	0.089	0.30	1	4	
11485+1633	HEI 158	2015.339	280.48	0.055	1.602	0.012	1.17	1	23	
11551+4629	STF1579A, D	2013.862	113.77	0.009	63.009	0.012	0.38	4	183	
11551+4629	STF1579A, D	2014.285	113.78	0.009	63.032	0.011	0.35	4	147	
11551+4629	STF1579A, C	2013.862	41.79	0.045	3.869	0.003	1.92	4	183	
11551+4629	STF1579A, C	2014.291	41.88	0.091	3.868	0.007	1.88	4	142	
13309+2414	H 570AC	2013.405	256.36	0.033	76.929	0.028	0.13	1	41	
13309+2414	H 570AC	2014.296	256.35	0.008	77.004	0.013	0.27	4	171	
13309+2414	H 570AC	2015.370	256.31	0.014	77.060	0.021	0.11	4	148	
13309+2414	STT 268AB	2013.776	75.95	0.018	19.023	0.009	4.19	2	70	
13309+2414	GAT 2Ba, Bb	2014.000	32.58	0.921	1.500	0.039	0.27	2	31	
13504+2117	S 656	2014.452	208.22	0.011	85.682	0.020	0.34	1	103	
13504+2117	S 656	2015.348	208.24	0.013	85.714	0.021	0.47	2	86	
14538-0024	STTA131AB	2013.447	215.50	0.018	83.137	0.031	0.47	1	67	
14538-0024	STTA131AB	2014.358	215.48	0.014	83.093	0.022	0.51	2	140	
14538-0024	STTA131AB	2015.370	215.52	0.018	83.071	0.026	0.48	1	49	
14596+5352	SHJ 191	2013.403	341.51	0.021	40.371	0.016	0.90	2	51	
14596+5352	SHJ 191	2014.274	341.43	0.021	40.365	0.019	0.80	1	31	
14596+5352	SHJ 191	2015.337	341.44	0.022	40.325	0.022	0.87	2	72	
16060+1319	STF2007AB	2013.474	322.07	0.032	38.316	0.028	1.30	3	106	16
16060+1319	STF2007AB	2014.424	322.00	0.015	38.363	0.012	1.30	4	199	
16060+1319	STF2007AB	2015.404	321.92	0.016	38.383	0.017	1.28	2	176	
16406+0413	STFA 31AB	2013.482	229.49	0.012	69.667	0.016	1.01	4	113	
16406+0413	STFA 31AB	2014.403	229.45	0.011	69.650	0.015	1.03	5	244	
16406+0413	STFA 31AB	2015.414	229.45	0.014	69.641	0.018	1.04	4	268	
18448+3736	STFA 38AD	2013.638	149.93	0.017	43.711	0.016	1.20	4	121	
18448+3736	STFA 38AD	2014.504	149.91	0.010	43.680	0.009	1.24	3	253	
18448+3736	STFA 38AD	2015.548	149.87	0.019	43.661	0.018	1.28	1	102	
18483+5752	STI2390AC	2012.459	98.70	0.294	5.012	0.203	2.14	1	22	17
18483+5752	STI2390AC	2013.572	99.05	0.135	5.063	0.015	2.57	1	30	
18483+5752	STI2390AC	2014.921	99.33	0.239	5.022	0.018	2.18	1	39	
18483+5752	GAT 3AB	2012.459	114.10	0.330	2.228	0.019	1.60	1	26	18
18483+5752	GAT 3AB	2013.572	115.48	0.273	2.341	0.010	1.88	1	30	
18483+5752	GAT 3AB	2014.858	117.15	0.229	2.251	0.026	1.66	1	33	
19126+1651	STTA177AC	2013.592	276.37	0.031	98.437	0.038	0.26	1	40	19
19126+1651	STTA177AC	2014.510	276.32	0.008	98.289	0.017	0.15	4	253	
19126+1651	STTA177AC	2015.588	276.20	0.009	98.135	0.018	0.14	3	282	
19126+1651	BU 139AB	2014.468	132.03	0.414	0.538	0.005	0.47	3	119	20
19126+1651	BU 139AB	2015.392	135.77	3.934	0.561	0.078	0.29	1	14	
19153+1505	STTA178	2015.458	267.05	0.010	89.790	0.018	3.00	1	106	
19307+2758	STFA 43AB	2013.636	54.10	0.028	34.606	0.030	3.26	2	63	
19307+2758	STFA 43AB	2014.657	54.01	0.013	34.581	0.009	3.29	3	237	

Table 1 concludes on next page.

## Near IR Measures II, 9-12hr and Reference Stars

Table I (conclusion). Measurements

WDS	NAME	DATE	PA	sePA	SEP	seSEP	Ia-b	N	exp	nt
19428+3741	STTA188AB	2013.628	121.03	0.021	60.607	0.025	1.23	3	109	
19428+3741	STTA188AB	2014.490	120.98	0.009	60.649	0.012	1.26	3	254	
19428+3741	STTA188AB	2015.591	120.98	0.009	60.665	0.011	1.26	2	235	
20099+2055	STF2637AC	2013.652	221.55	0.018	90.972	0.032	0.25	2	36	
20099+2055	STF2637AC	2014.529	221.55	0.009	91.038	0.017	0.30	3	209	
20099+2055	STF2637AC	2015.455	221.55	0.009	91.155	0.017	0.29	1	94	
20099+2055	STF2637AB	2013.652	331.09	0.055	11.615	0.016	2.07	1	30	
20099+2055	STF2637AB	2015.455	331.17	0.031	11.616	0.008	2.06	1	95	
20229+4259	STTA207AC	2013.710	64.63	0.010	85.778	0.018	2.52	2	59	
20229+4259	STTA207AC	2015.707	64.63	0.009	85.639	0.017	2.61	2	180	21
20229+4259	HO 128AB	2013.710	357.97	0.336	1.283	0.017	2.70	1	13	
20229+4259	HO 128AB	2015.668	357.63	0.238	1.352	0.006	2.51	2	64	22
20302+1925	S 752AC	2013.677	288.00	0.010	106.258	0.023	0.47	1	43	
20302+1925	S 752AC	2014.433	287.93	0.008	106.234	0.017	0.44	3	87	
20302+1925	S 752AC	2015.567	287.98	0.008	106.320	0.018	0.41	3	251	
22093+4451	HJ 1735	2013.721	285.65	0.008	109.960	0.019	0.02	5	148	
22093+4451	HJ 1735	2015.458	285.60	0.011	110.160	0.024	0.23	1	60	
22237+2051	STF2900AC	2013.742	306.09	0.011	92.180	0.021	2.47	4	302	
22237+2051	STF2900AC	2014.658	305.99	0.011	92.386	0.022	2.42	1	93	
22237+2051	STF2900AC	2015.668	305.81	0.009	92.665	0.018	2.51	1	84	
22237+2051	STF2900AB	2013.759	178.37	0.202	0.659	0.020	1.65	1	23	23
22237+2051	STF2900AB	2015.668	179.93	0.225	0.749	0.022	2.01	1	13	
23300+5833	SHJ 355AC	2011.806	268.71	0.013	75.558	0.016	2.18	3	100	
23300+5833	SHJ 355AC	2013.770	268.64	0.011	75.601	0.017	2.30	6	268	
23300+5833	SHJ 355AC	2014.658	268.64	0.011	75.590	0.019	2.16	1	102	
23300+5833	SHJ 355AC	2015.557	268.61	0.010	75.651	0.017	2.35	2	190	
23300+5833	DA 2CD	2015.625	213.07	0.296	1.301	0.012	1.72	2	43	
23592+5032	ARY 33	2011.901	139.24	0.010	100.160	0.023	0.89	2	106	
23592+5032	ARY 33	2013.783	139.19	0.013	100.091	0.025	0.76	4	229	
23592+5032	ARY 33	2014.658	139.20	0.011	100.099	0.019	0.76	1	99	
23592+5032	ARY 33	2015.668	139.17	0.009	100.075	0.017	0.80	1	90	

## Notes:

All observations were obtained using a F/6.63 16 inch Newtonian telescope and a Barlow lens yielding an effective focal length of 374 inches. A SBIG 402 CCD with standard B, V and I filters was used for all imaging.

- dMv=0.032, 92i, 33v
- dMv=1.01, 43i, 10v. No apparent occultation noted.
- dMv=0.09, 18i, 7v, on about half of the I band exposures B has more counts than A.
- dMv=1.41, 25i, 5v
- dMv=0.09, 23i, 3v
- dMv=1.88, 17i, 11v, significant change since 1988.
- GAT 4, dMv=2.37, 23i, 5v, somewhat different than Paper 1.
- dMv=0.18, 23i, 9v
- dMv=0.97, 21i, 7v
- SEP is less than 0.5 arc sec. The image is round on a set of very good exposures. We note that the star was only observed as double once and we suspect that was a mistake such as recording the wrong star number with the observation.
- dMv=0.60, 13i, 7v
- UC2134AC, dMv=1.38, 22i, 8v. HEI195 may be UC 2134AC.
- dMv=0.57, 13i, 13v
- dMv=1.44, 59i, 20v
- GAT 5, significant motion in angle may be from relative proper motion.
- dMv=1.12, dMb=1.28, 481i, 24v, 27b
- STI2390AC, dMv= 2.63, 69i, 22v, motion in angle may be from relative proper motion.

**Near IR Measures II, 9-12hr and Reference Stars**

18. GAT 3,  $dM_v = 1.82$ , 84i, 5v, motion in angle may be from relative proper motion.
19. STTA177AC, 3<sup>rd</sup> close star makes this system difficult to measure. Space borne measurements will likely differ from ground based measurements. It was dropped from our Reference Star list.
20. BU139AB, this pair is close to the near-IR diffraction limit of our 16 inch. Although well resolved our measurements are likely to suffer from adjacency effects. But hey, since we made the mirror ....
21. STTA207AC,  $dM_v = 1.72$ ,  $dM_b = 1.07$ , 180i, 85v, 63b, the C companion is relatively very blue.
22. HO128AB,  $dM_v = 2.44$ ,  $dM_b = 2.09$ , 35i, 33v, 9b
23. STF2900AB, the magnitude difference and proximity make this a difficult pair. Our measurements are likely to suffer from adjacency effects.



# Double Star Measurements of Beta Scorpii

Sean Gillette<sup>1,2</sup>, Benjamin Funk<sup>3</sup>, Ruth Schlosser<sup>3</sup>, Alana Brown<sup>4</sup>, Mallikai Cruz<sup>4</sup>, Jeff McCarthy<sup>5</sup>, Breana Rhoades<sup>3</sup>, Bill Spreng<sup>6</sup>

1. Vanguard Preparatory School
2. High Desert Research Initiative
3. Apple Valley High School
4. Victor Valley College
5. High Desert Astronomical Society
6. Victor Valley Young Marines

**Abstract:** Eight observers met at the Lewis Center for Educational Research in Apple Valley, California. These observers studied the distance and position angle between  $\beta^1$  and  $\beta^2$  of the beta Scorpii star system. They used the drift method to calibrate the telescope-eyepiece, which was a Celestron C8 Schmidt-Cassegrain telescope equipped with an astrometric eyepiece. The star system  $\gamma$  Cassiopeiae was used to determine the scale constant of 4.6 arcseconds per division mark, using the average of twelve observations made of the star system using the drift method. A separation of 15.4 arcseconds and a position angle of 14.3 was determined using a Bader Planetarium Micro Guide eyepiece with marking similar to a Celestron Micro Guide eyepiece. A large difference was found compared to WDS due in part to a smoky sky, an incoming storm, and the novice level of the team members, who had a difficult time reading the labels on the eyepiece.

## Introduction

A team of students (shown in Figure 1) made observations and took measurements of the double star  $\beta$  Scorpii at a three-day Apple Valley Double Star workshop that was held by the High Desert Astronomical Society (HiDAS) and the Antelope Valley Astronomy Club at the Lewis Center's Luz Observatory in Apple Valley, California on July 17, 2015. On the night that the observations were made, the sky was clear, except for there being some smoke visible in the western sky, which had a slightly negative effect on the quality of observations.

In the Washington Double Star Catalog (WDS, 2015),  $\beta$  Scorpii is identified as H 3 7AC. The right ascension and declination are listed as 160526.23-194819.4. The magnitudes of the primary and secondary stars are 2.59 and 4.52 respectively.

## Equipment and Procedures

The telescope used was a Celestron C8 Schmidt-Cassegrain telescope (Figure 2) equipped with a 12.5mm Baader Micro Guide astrometric eyepiece, and



Figure 1: Team members from left to right: Ruth Schlosser, Bill Spreng, Jeff McCarthy, Sean Gillette, Alana Brown, Breana Rhoades, and Benjamin Funk.

### Double Star Measurements of Beta Scorpii

mounted on German equatorial. The drive system was a Celestron Advanced VX. A 2x Barlow lens was used.

To determine the scale constant, the observers focused the telescope on  $\gamma$  Cassiopeiae, or Navi, in the constellation Cassiopeia. They aligned this star on the linear scale of the Micro Guide eyepiece and turned the drive motor off, allowing the star to drift along the linear scale. Once the star reached the beginning of the scale, a stopwatch accurate to the nearest hundredth of a second was started. The observer watched the star drift and alerted the other team member to stop the watch once the star had drifted off of the scale. This was repeated twelve times to reach an average, standard deviation, and standard mean of the error.

The following equation was used to determine the scale constant:

$$Z = \frac{(15.0411)(t) \cos(dec)}{D}$$

where  $Z$  is the scale constant in arc seconds per division; 15.0411 is the Earth's rotational rate in arcseconds per second,  $t$  is the average drift time in seconds,  $dec$  is the declination of the calibration star in degrees, and  $D$  is the number of division marks on the linear scale (60).

The team then aligned  $\beta$  Scorpii along the linear scale and counted the tic marks between  $\beta^1$  and  $\beta^2$  to find the number of separation divisions. This was repeated 10 times for an average, standard deviation, and standard mean of the error.

The observers positioned the primary star on the center of the linear scale and turned off the drive motor, allowing the star system to drift to the inner protractor. The drive motor was turned back on and the position angle was recorded to the nearest half degree. The process was repeated 10 times to determine an average, standard deviation, and standard mean of the error.

#### Observation and Analysis

Observations were completed (B2015.54074) from the Lewis Center for Educational Research in Apple Valley, California between the hours of 9 PM and 11 PM, on Saturday, July 17, 2015. The evening tempera-



Figure 2. The telescope used by the observers - Celestron C8 Schmidt-Cassegrain with Advanced VX Mount

ture was approximately 80 degrees and the sky conditions were good but with smoke in the western sky that had a small impact on the observations. The completed observations were made during a waxing crescent moon that had not yet risen and with low light pollution.

#### Conclusion

The team found a scale constant of 4.56 arcseconds per division mark with a standard deviation of 1.19. The observer's average separation division was 15.3 arcseconds which was a percentage difference of 14.1% off from the WDS observations. The team found a position angle of 14.3° which was 30.8% off from the WDS observations.

The difference between our measurements and the published values was greater than the observers antici-

Table 1: Observations on Double Star System  $\beta$  Scorpii. All measurements made on 2015.542.

Parameters	# Obs	Mean	SD	Standard Error of Mean	WDS Value	Difference	% Difference
Scale Constant a.s. / division	12	37.17	1.19	0.34	NA	NA	NA
Separation (a.s.)	10	15.4"	0.50"	.16"	13.4"	1.9"	14.1%
Position Angle (degrees)	10	14.3°	6.92°	2.19°	19°	5.87°	30.8%

## Double Star Measurements of Beta Scorpii

pated. This may have been because the observers had a difficult time reading the labels on the Micro Guide eyepiece, as well as the novice level of many of the team members.

### Acknowledgements

The observers would like to thank Mark Brewer, the High Desert Astronomical Society, and the Antelope Valley Astronomy Club. The observers would also like to thank the Lewis Center for Educational Research for letting us use their facility, Walmart for their gracious donations, and Starbucks for their food donations. Special thanks goes to Tom Frey and Joseph Carro for external review of this paper.

### References

Mason, Brian D.; Hartkopf, William I.; Tokovinin, Andrei, 2010, "Binary Star Orbits. IV. Orbits of 18 Southern Interferometric Pairs", *The Astronomical Journal*, **140**, 735-743.

Washington Double Star Catalog, 2015, Retrieved from <http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/wds/WDS>



# Measurements of Some VizieR I/330 Objects

Wilfried R.A. Knapp

Vienna, Austria

[wilfried.knapp@gmail.com](mailto:wilfried.knapp@gmail.com)

**Abstract:** Data Mining is a contemporary form of double star detection – software running over a star catalog with proper motion data producing long lists of newly detected pairs, most of them rather wide and faint and thus of little interest for the visual observer. For evaluation of such an approach I measured a random sample (selected by altitude suitable for imaging) of objects from the VizieR I/330 “Binary star discoveries in the URAT1 catalog” (Nicholson, 2015). Without exception the astrometry results were rather close to the I/330 catalog values proving the reliability of the provided data but in total several questions arose regarding the validity of Nicholson study.

## Report

Martin P. Nicholson published 2015 at Amazon.com his work “Binary star discoveries in the URAT1 catalog - separation under 60 arc sec” presenting 9450 common proper motion binary star systems found in the first U.S. Naval Observatory Astrometric Robotic Telescope Catalog (URAT1) and this work was included in the VizieR database of star catalogs as I/330. The reported objects are accordingly to the author newly discovered pairs but are so far (begin of 2016) not included in the WDS catalog as USNO considers URAT1 as preliminary and this work of Nichol-

son as published without peer review. A first look into the printed version made me curious because the given separation and position angles did not match precisely with the given RA Dec position data. For this reason and also for a general countercheck for the delivered overall data quality I selected a few objects in the Boo constellation rather high in the northern skies at the time of this research with separation and magnitudes suitable for resolution with remote telescope iT18 (see specifications in the acknowledgements). In one case the components were much fainter than expected so I had to resort to remote telescope iT24 with larger aperture (see specifications in the acknowledgements). The

Table 1: VizieR I/330 Catalog Values per Beginning of 2016 for the Selected I/330 Objects Intended for Measurement

I/330#		RA	Dec	Sep	fmag1	fmag2	PA
4868	AB	14:09:46.200	+44:53:41.6	4.73	12.56	13.28	245
4969	AB	14:19:13.464	+42:23:19.3	7.59	10.02	10.46	130
4983	AB	14:20:56.904	+34:59:51.4	28.03	9.61	11.04	278
4986	AB	14:21:05.448	+49:42:18.7	9.64	11.57	12.41	316
5003	AB	14:23:46.032	+47:01:10.9	5.18	12.51	13.08	92
5204	AB	14:48:45.360	+32:32:23.3	10.67	11.41	12.74	42
5211	AB	14:49:27.936	+45:16:50.2	7.32	10.3	11.6	180
5229	AB	14:52:12.672	+31:02:07.8	12.04	11.87	13.44	187
5241	AB	14:53:32.208	+42:04:12.4	48.27	10.66	12.08	357
5359	AB	15:09:41.592	+49:41:46.0	25.13	11.01	11.43	65
5368	AB	15:10:15.840	+30:44:08.2	10.83	11.99	12.44	349
5398	AB	15:13:28.296	+38:59:50.3	9.70	13.13	13.41	272
5399	AB	15:13:39.528	+42:14:46.7	30.69	11.54	12.37	232
5447	AB	15:18:46.152	+43:13:50.9	16.19	12.81	13.12	27
5467	AB	15:20:58.704	+50:46:29.3	17.26	10.57	12.63	292

Measurements of Some VizieR I/330 Objects

weather was not very cooperative so it took some time to get all images and in some cases I had to settle with less than 5 images for stacking. The star fields are mostly rather modest populated so the number of available reference stars for plate solving was also rather limited.

The current (begin of 2016) I/330 catalog data for these objects is listed in Table 1.

The measurement results are given in Table 2. The RA/Dec coordinates resulting from plate solving with URAT1 reference stars in the 10.5 to 14.5 magnitude range were used to calculate Sep and PA using the formula provided by R. Buchheim (2008). *Err\_Sep* is calculated as

$$Err\_Sep = \sqrt{dRA^2 + dDec^2}$$

with *dRA* and *dDec* as average RA and Dec plate solving errors. *Err\_PA* is the error estimation for PA calculated as

$$Err\_PA = \arctan\left(\frac{Err\_Sep}{Sep}\right)$$

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 URAT1 reference stars with *Vmags* between 10.5 and 14.5mag. *Err\_Mag* is calculated as

$$Err\_Mag = \sqrt{dVmag^2 + [2.5 \log_{10}(1 + 1/SNR)]^2}$$

with *dVmag* as the average *Vmag* error over all used reference stars and *SNR* the signal to noise ratio for the given star. Date is the Bessel epoch of the observation and *N* is the number of images used for the reported values. The Notes column provides additional information about the used image:

In total, most astrometry results agree very well with the given separation and position angle. The photometry results differ from the given *fmags* for good reasons significantly and are at least for several components the first measurements with V-filter – for many components APASS *Vmags* were already available. I then checked the availability of CPM suggesting proper motion data in the UCAC4 catalog and found that in most cases this data was already given. Some examples are given in Figures 1 through 3.

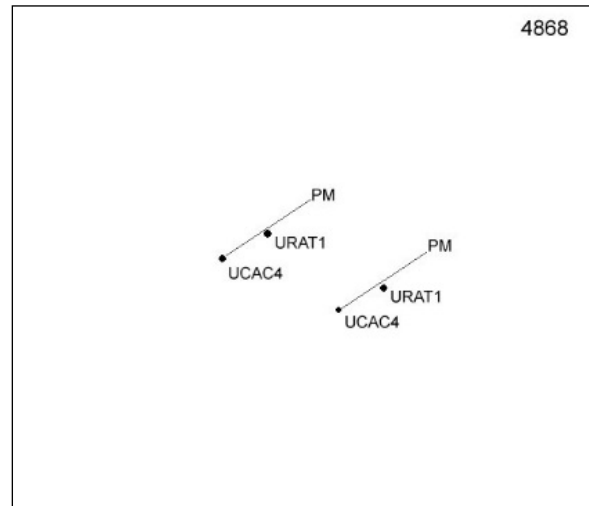


Figure 1. I/330 object 4868 - comparison UCAC4 with URAT1 positions with proper motion UCAC4 vector.

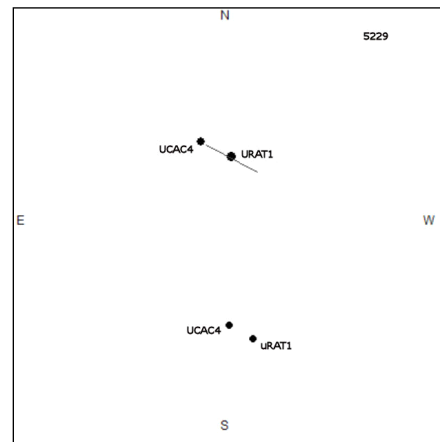


Figure 2. I/330 object 5229 - comparison UCAC4 with URAT1 positions with proper motion UCAC4 vector for only one component.

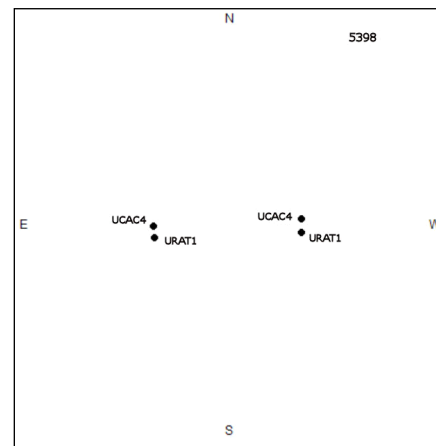


Image 3: I/330 object 5398 - comparison UCAC4 with URAT1 positions with no proper motion UCAC4 vector for both components but obvious movement between UCAC4 and URAT1 observations

(Continued on page 592)

Measurements of Some VizieR I/330 Objects

Table 2: Photometry and Astrometry Results for the Selected Objects

	RA	Dec	dRA	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
MPN 4868	A 14 09 46.176	44 53 41.61	0.08	4.623	0.100	248.560	1.239	14.085	0.047	44.75	0.04	2016.319	5	iT24 stack 5x6s
	B 14 09 45.771	44 53 39.92						15.073	0.057	26.24				
MPN 4869	A 14 19 13.464	42 23 19.42	0.14	7.548	0.191	130.379	1.450	10.319	0.092	53.51	0.09	2016.266	2	iT18 stack 2x3s
	B 14 19 13.983	42 23 14.53						10.714	0.093	45.08				
MPN 4983	A 14 20 56.888	34 59 51.29	0.09	28.029	0.098	277.978	0.201	10.053	0.072	61.00	0.07	2016.266	4	iT18 stack 4x3s
	B 14 20 54.629	34 59 55.18						12.004	0.083	24.00				
MPN 4986	A 14 21 05.448	49 42 18.83	0.11	9.897	0.228	316.676	1.321	12.025	0.077	21.78	0.06	2016.266	3	iT18 stack 3x3s. SNR B<20
	B 14 21 04.748	49 42 26.03						13.438	0.119	10.08				
MPN 5003	A 14 23 45.987	47 01 10.65	0.10	4.765	0.135	89.760	1.617	14.065	0.157	7.00	0.06	2016.266	5	iT18 stack 5x3s. SNR A and B<10
	B 14 23 46.453	47 01 10.67						14.632	0.200	5.20				
MPN 5204	A 14 48 45.340	32 32 23.30	0.08	10.724	0.113	42.233	0.604	11.699	0.088	29.56	0.08	2016.266	4	iT18 stack 4x3s. SNR B<10
	B 14 48 45.910	32 32 31.24						13.519	0.133	9.72				
MPN 5211	A 14 49 27.895	45 16 50.26	0.08	7.324	0.094	181.899	0.738	10.962	0.084	40.86	0.08	2016.266	3	iT18 stack 3x3s. SNR B<20
	B 14 49 27.872	45 16 42.94						12.718	0.104	15.66				
MPN 5229	A 14 52 12.652	31 02 07.95	0.10	11.956	0.135	186.481	0.645	12.226	0.094	21.53	0.08	2016.266	4	iT18 stack 4x3s. SNR B<5
	B 14 52 12.547	31 01 56.07						14.962	0.317	3.06				
MPN 5241	A 14 53 32.177	42 04 12.31	0.07	48.280	0.092	357.383	0.109	11.104	0.085	37.87	0.08	2016.266	5	iT18 stack 5x3s. SNR B<20
	B 14 53 31.979	42 05 00.54						12.920	0.104	15.84				
MPN 5359	A 15 09 41.598	49 41 45.31	0.12	25.128	0.150	65.951	0.342	11.604	0.079	29.04	0.07	2016.266	3	iT18 stack 3x3s. SNR B<20
	B 15 09 43.963	49 41 55.55						12.362	0.089	19.50				
MPN 5368	A 15 10 15.819	30 44 08.68	0.05	10.645	0.139	349.603	0.750	12.381	0.087	16.92	0.06	2016.266	2	iT18 stack 2x3s. SNR A and B<20
	B 15 10 15.670	30 44 19.15						12.766	0.095	14.19				
MPN 5398	A 15 13 28.273	38 59 49.46	0.11	9.596	0.163	278.993	0.972	13.825	0.166	6.71	0.07	2016.266	3	iT18 stack 3x3s. SNR A and B<10
	B 15 13 27.460	38 59 50.96						14.093	0.163	6.86				
MPN 5399	A 15 13 39.547	42 14 46.34	0.12	30.705	0.150	232.951	0.280	11.828	0.099	26.02	0.09	2016.266	3	iT18 stack 3x3s. SNR B<20
	B 15 13 37.340	42 14 27.84						12.780	0.113	15.32				
MPN 5447	A 15 18 46.136	43 13 50.64	0.04	16.266	0.064	26.712	0.226	14.050	0.157	7.54	0.08	2016.266	5	iT18 stack 5x3s. SNR A and B <10
	B 15 18 46.805	43 14 05.17						14.100	0.174	6.53				
MPN 5467	A 15 20 58.680	50 46 29.50	0.06	16.961	0.072	291.732	0.244	10.779	0.174	43.74	0.07	2016.266	2	iT18 stack 2x3s. SNR B <10
	B 15 20 57.019	50 46 35.78						13.389	0.297	9.49				

## Measurements of Some VizieR I/330 Objects

(Continued from page 590)

### Summary

As already mentioned: A first look into the printed version of the Nicholson 2015 study made me curious because the given separation and position angles did not match precisely with the given RA Dec position numbers – only when comparing these numbers with the online VizieR I/330 data I found that this was due to the limited number of digits after the decimal point given in the printed version. Another point to be aware of is the mismatch of object numbers between the printed version and the VizieR I/330 online catalog – the reason for this is probably the fact that the online catalog includes more objects (9450 objects vs. 9590 objects).

Regrettable is the disregard for many objects existing APASS Vmags; repeating given fmags from the URAT1 catalog is not valuable information. Just running software over one single open source star catalog and presenting the results without extensive further counterchecks with other catalogs (besides the WDS catalog for eliminating already included objects) or other individual work looks like a very limited approach. Curious also is the fact that URAT1 would not have been necessary for this data mining project – the required proper motion data was already available in UCAC4 for most of the listed objects.

The criteria used for the detection of common proper motion pairs are not described in full detail in the form of formulas according to, for example, Halbwachs 1986. Nicholson gives in his printed Amazon.com study as minimum CPM requirement a proper motion of 60 mas/yr (opposed to the usual accepted 50 mas/yr – may be to make sure to fulfill the Halbwachs 1986 criterion separation/pm < 1000 up to 60" separation) and excludes all stars with a difference in pm in either Dec or RA greater than the given URAT1 errors. As countercheck, I decided to try a new approach by comparing the UCAC4 and URAT1 positions directly. Only if the position change between these two observation epochs has the same direction and same distance for both components within the average UCAC4 position error of ~0.05" then CPM is considered as confirmed.

Nicholson claims to have done a countercheck with the WDS catalog to reduce his list to newly "discovered" pairs but obviously several objects slipped through this control as I found most objects listed here already present in the WDS catalog as described in Table 3.

For counter counterchecking I also looked at the Nicholson 2006 JDSO paper on CPM pairs and immediately the first newly discovered reported object is included in the WDS catalog as LEP2 discovered 1902.

Table 4: Cross-reference I/330 with WDS Catalog for the first 100 I/330 objects

VizieR I/330#	WDS object
6	CBL 556
22	SKF2456
25	CBL 560
33	CBL 562
40	CBL 563
47	CBL 566
60	CBL 567
66	CBL 568
97	CBL 574
98	CBL 575

So there seems to be a systematic error in Nicholson's process of filtering out the already known WDS pairs.

As an additional check I looked at the first 100 objects in the I/330 catalog and found 10 of them already present in the WDS catalog. A cross-reference of these 10 objects is given in Table 4.

### Addendum

I contacted Martin Nicholson by email asking for a comment to my findings and his statement was "I think perhaps you have misunderstood the scope of the listing - nowhere does it say they are all new discoveries. In fact it quite clearly says they are not". This is a somewhat contradicting statement to the printed version Nicholson 2015 describing his procedure finishing with his last step at page 6: "Cross reference the results obtained with the latest on-line version of the WDS catalogue so that all the known double stars could be removed from the output file leaving only the new discoveries to be presented in this paper". In a second email he then stated that there is a difference between the printed and the online version of his catalog and that the printed version is cross checked with WDS and the online version not. A final countercheck for the in Table 4 listed objects then showed that the printed version includes also very well all of the above indicated WDS CPM pairs.

### Acknowledgements

The following tools and resources have been used

(Continued on page 594)

### Measurements of Some VizieR I/330 Objects

*Table 3: Cross-reference between WDS catalog with VizieR I/330 – 11 out of 15 objects are already known as WDS objects. In the Notes column additional data for each object from APASS, UCAC4 and URAT1 is given if available. “CPM confirmed by comparison URAT1 and UCAC4 positions” in the Notes column means that by comparing UCAC4 and URAT1 positions both angular distance and direction are (within the average UCAC4 position error of ~0.05”) ident for both components. WDS objects with both components included in UCAC4 catalog are also listed in the VizieR catalog J/AJ/146/76 Astrometry and photometry of UCAC4 double stars (Hartkopf+, 2013). The column WDS Code V (CPM) indicates with “Yes” if this objects is already marked as CPM pair in the WDS catalog*

MPN		WDS ID	WDS Name	WDS RA	WDS Dec	WDS Sep	WDS M1	WDS M2	WDS PA	Notes	WDS Code V (CPM)
4868	AB	14098+4454	UC2692	14:09:46.361	+44:53:40.7	4.7	13.50	13.70	245	1	Yes
4969	AB	14192+4223	AG193	14:19:13.599	+42:23:19.3	7.6	10.28	10.95	130	2	Yes
4983	AB	14209+3500	HJ547	14:20:56.949	+34:59:52.4	28.2	10.43	11.98	293	3	-
4986	AB	14211+4942	UC193	14:21:05.501	+49:42:19.9	9.6	12.22	12.80	317	4	Yes
5003	AB	-	-	-	-	-	-	-	-	5	-
5204	AB	-	-	-	-	-	-	-	-	6	-
5211	AB	14495+4517	HDS2093	14:49:28.139	+45:16:50.1	7.4	11.06	13.06	181	7	Yes
5229	AB	14522+3101	LDS969	14:52:12.820	+31:02:08.5	12.0	12.39	14.90	187	8	-
5241	AB	-	-	-	-	-	-	-	-	9	-
5359	AB	15097+4942	BEM16	15:09:41.541	+49:41:47.5	25.1	11.58	12.31	66	10	-
5368	AB	15103+3044	LDS972	15:10:15.911	+30:44:07.2	10.8	12.90	13.30	350	11	-
5398	AB	-	-	-	-	-	-	-	-	12	-
5399	AB	15136+4215	LDS4537	15:13:39.570	+42:14:48.3	30.7	11.84	12.74	233	13	-
5447	AB	15188+4314	UC203	15:18:46.239	+43:13:51.9	16.1	13.51	13.90	28	14	Yes
5467	AB	15210+5046	UC2988	15:20:58.800	+50:46:28.7	17.3	10.70	13.00	292	15	Yes

#### Table 3 Notes

- APASS 13.67 Vmag for A. Proper motion data already in UCAC4 available and CPM confirmed by comparison URAT1 and UCAC4 positions.
- No APASS Vmag. Proper motion data already in UCAC4 available and CPM confirmed by comparison URAT1 and UCAC4 positions. WDS cross reference with CPM pair HJL 201.
- No APASS Vmag. Proper motion data already in UCAC4 available and CPM confirmed by comparison URAT1 and UCAC4 positions.
- APASS 12.00 Vmag for A. Proper motion data already in UCAC4 available and CPM confirmed by comparison URAT1 and UCAC4 positions.
- APASS 13.45 Vmag for A. No WDS catalog object. No proper motion data in UCAC4 for A. Position comparison between UCAC4 and URAT1 results in proper motion with same direction and distance even if slightly outside the UCAC4 measurement error – CPM rather confirmed.
- APASS 11.66 Vmag for A. No WDS catalog object. No proper motion data in UCAC4 for B. Position comparison between UCAC4 and URAT1 results in proper motion with same direction but different distance outside the UCAC4 measurement error range. Difference might be explained by the fact that UCAC4 for A is epoch 1991.675 while 2001.55 for B but also the difference per year remains significant - CPM not confirmed.
- APASS 10.84 Vmag for A. Proper motion data already in UCAC4 available and CPM confirmed by comparison URAT1 and UCAC4 positions.
- APASS 12.20 Vmag for A. No proper motion data in UCAC4 for B. Position comparison between UCAC4 and URAT1 results in proper motion with same vector direction but different vector length outside the UCAC4 measurement error range. Difference might be explained by the fact that UCAC4 for A is epoch 1986.41 while 2002.14 for B but also the difference per year remains significant - CPM not confirmed.
- APASS 11.08/12.02 Vmag. No WDS catalog object. Proper motion data already in UCAC4 available and CPM confirmed by comparison URAT1 and UCAC4 positions.
- APASS 11.58/12.31 Vmag. Proper motion data already in UCAC4 available and CPM confirmed by comparison URAT1 and UCAC4 positions.
- APASS in between the two components 12.14 Vmag. Proper motion data already available in UCAC4. CPM confirmed by comparison URAT1 and UCAC4 positions.
- APASS in between the components 13.67 Vmag. No WDS catalog object. Variable star VSX284415 for B. No proper motion data in UCAC4. CPM confirmed by comparison URAT1 and UCAC4 positions.
- APASS 11.84/12.74 Vmag. Proper motion data already in UCAC4 available. CPM confirmed by comparison URAT1 and UCAC4 positions.
- No APASS value. Proper motion data already in UCAC4 available and CPM confirmed by comparison URAT1 and UCAC4 positions.
- APASS 10.74 Vmag for A. Proper motion data already in UCAC4 available and CPM confirmed by comparison URAT1 and UCAC4 positions.

## Measurements of Some VizieR I/330 Objects

(Continued from page 592)

for this research:

- Washington Double Star Catalog as data source for the selected objects
- iTelescope: Images were taken with
- iT18: 318mm CDK with 2541mm focal length. CCD: SBIG-STXL-6303E. Resolution 0.73 arcsec/pixel. V-filter. Located in Nerpio, Spain. Elevation 1650m
- iT24: 610mm CDK with 3962mm focal length. CCD: FLI-PL09000. Resolution 0.62 arcsec/pixel. V-filter. Located in Auberry, California. Elevation 1405m
- AAVSO VPhot for initial plate solving and stacking
- AAVSO APASS providing Vmags
- 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 Survey Images for counterchecks
- AstroPlanner v2.2 for object selection, session planning and for catalog based counterchecks
- Astrometrica v4.9.1.420 for astrometry and photometry measurements

Special thanks to Paul Rodman (author of AstroPlanner) for providing me the current APASS catalog for local use with AstroPlanner

## References

- Buchheim, Robert, 2008, "CCD Double-Star Measurements at Altimira Observatory in 2007", *Journal of Double Star Observations*, **4**, 28-32.
- Halbwachs, J.L., 1986, "Common proper motion stars in the AGK3", *Astronomy and Astrophysics Supplement Series*, **66**, 131-148.
- Nicholson, Martin P., 2015, "Binary star discoveries in the URAT1 catalog - separation under 60 arc sec, Amazon.com. Abstract: Data mining using the recently published First U.S. Naval Observatory Astrometric Robotic Telescope Catalog (URAT1) has allowed the identification over 9400 common proper motion binary star systems many of which appear to be new discoveries
- Nicholson, Martin P., 2006, "Unreported High Proper Motion Northern Double Stars in the LSPM Catalog", *Journal of Double Star Observations*, **2**, 68-73.



***Journal of Double Star Observations***

*October 1, 2016*  
*Volume 12, Number 6*

***Editors***

*R. Kent Clark*  
*Rod Mollise*  
*Russ Genet*  
*Jo Johnson*

***Assistant Editors***

*Vera Wallen*

***Student Assistant Editor***

*Eric Weise*

***Advisory Editors***

*Brian D. Mason*  
*William I. Hartkopf*

***Web Master***

*Michael Boleman*

*The Journal of Double Star Observations is an electronic journal published quarterly. Copies can be freely downloaded from <http://www.jdso.org>.*

*No part of this issue may be sold or used in commercial products without written permission of the Journal of Double Star Observations.*

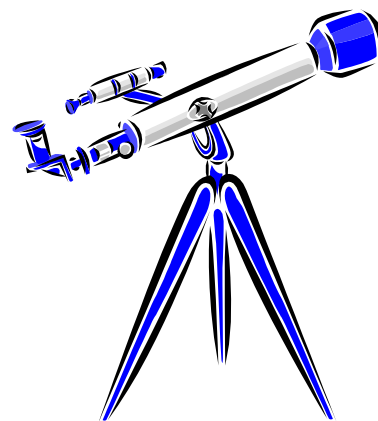
©2016 *Journal of Double Star Observations*

*Questions, comments, or submissions may be directed to [rclark@southalabama.edu](mailto:rclark@southalabama.edu) or to [rmollise@bellsouth.net](mailto:rmollise@bellsouth.net)*

The *Journal of Double Star Observations (JDSO)* publishes articles on any and all aspects of astronomy involving double and binary stars. The *JDSO* is especially interested in observations made by amateur astronomers. Submitted articles announcing measurements, discoveries, or conclusions about double or binary stars may undergo a peer review. This means that a paper submitted by an amateur astronomer will be reviewed by other amateur astronomers doing similar work.

Submitted manuscripts must be original, unpublished material and written in English. They should contain an abstract and a short description or biography (2 or 3 sentences) of the author(s). For more information about format of submitted articles, please see our web site at <http://www.jdso.org>

Submissions should be made electronically via e-mail to [rclark@southalabama.edu](mailto:rclark@southalabama.edu) or to [rmollise@bellsouth.net](mailto:rmollise@bellsouth.net). Articles should be attached to the email in Microsoft Word, Word Perfect, Open Office, or text format. All images should be in jpg or fits format.



*We're on the web!*

<http://www.jdso.org>