Double Star Measurements with an AltAz Telescope: Report for 2016

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Abstract: This article presents a set of double star measurements using a small AltAz computerised telescope and a DSLR camera during the year 2016.

The Telescope and the Camera:

I used a Celestron CPC 800 computerised AltAz mounted telescope and a Canon 1100D camera in order to obtain measurements for some double stars, part of them neglected, in many observing sessions during the entire year of 2016. This equipment is positioned in a fixed location, connected and remotely controlled thru a computer. This small fixed observatory is also used to do asteroid astrometry and is enrolled at the Minor Planet Center having the MPC code L13. The physical position is in Brasov, a medium city located in the center of Romania. The telescope is a SCT having a mirror with diameter of 200 mm and a focal of 2000 mm. The Canon camera is mounted in prime focus having a CMOS of 4272 × 2848 pixels. Through this setup, I can image fields having about 36 × 24 arcminutes with a resolution of 0.512 arcsecond per pixel. The current magnitude limit of the setup is up to 16 mag. A better magnitude limit could be obtained by increasing the exposure time, but because of the field rotation effect which occurs in AltAz mounted telescopes at medium and long exposures, I prefered to limit the exposures mostly to 30 seconds and very rarely to go up to 45 seconds. I also used a bahtinov mask to get sharp focusing.

The Method

Using the described setup I imaged fields centered on some neglected doubles selected from the WDS using a web-tool built by myself some years ago. This tool named WDSFilter [4] helped me to select double stars from the WDS [1] which meets different criteria. Using this tool, I isolated some neglected double stars visible to my fixed observatory because I have some limitations caused by local buildings near my home position. I also selected my targets requiring them to have a separation bigger than 5 arcseconds and magnitudes brighter than 16. The 5 arcseconds limit was used because I previously performed some precision tests around 5 arcseconds separation which showed that 5 arcseconds or higher separated doubles can produce results with a good enough precision for double star astrometry. The precision results will be presented in the next paragraph.

Because my camera field is pretty big next to the targeted neglected doubles I also measured some other doubles that were occasionally in my imaged fields or in fields imaged for other purposes like the asteroid work that I also do.

In order to obtain the measurements, I imaged fields centered on the coordinates of each targeted object. Each picture was saved as raw image at first on the observatory computer and then it was converted to grayscale PNG and after that converted to FITS using the Astrometry.net webtool [7]. The resulted FITS was reduced using Astrometrica [2] software measuring there the precise position (RA and DEC) of each targeted object components. The obtained coordinates I've inserted in a google spreadsheet taken from an older double star project presented in a JDSO article in the past [5]. This spreadsheet computes the separation and position angle from the coordinates. In Astrometrica I used the UCAC4 catalogue [6] for field matching.

Measurements Precision

Some basic computations based on the equipment

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Table 1. Measurements comparison between my determinations and WDS values.

Name	RA+Dec	Measured PA	Measured Sep	WDS PA	WDS Sep	PA O-C	Sep O-C
DAM 942	17103+2856	281.8514050	4.869160858	281.6	4.96	0.251405041	-0.09083914
UC 3340	17264+1352	89.3172991	6.714171699	90.6	6.7	-1.282700865	0.01417170
STF3086	14323+1718	270.6470147	5.313356728	271.2	5.72	-0.552985314	-0.40664327
BAL1899	14286+0144	235.5691116	6.198730270	236.8	6.02	-1.230888395	0.17873027
J 1611	14121-0846	338.1479712	6.187944533	337.5	6.47	0.647971162	-0.28205547

characteristics suggested to me that I shall be able to get good enough accuracy for double stars down to a few arcseconds, but I wanted to confirm this by test measurements. I first decided to test the accuracy around 5 - 6 arcseconds and I selected 5 low speed doubles with recent measurements and separation close to my target separation limit. Initially I planned to use some calibration doubles for this process, but unfortunately I was unable to find appropriate objects to meet both separation and visibility constraints for my observatory in the desired timeframe. I present the list of these measurements in Table 1. For a better overview of the results, I also built two graphs presenting the PA differences (Figure 1) and separation differences (Figure 2).

As can be seen in the presented data and graphs, the average errors are 0.79 degrees in PA and 0.19 arcseconds in separation. Maximal errors obtained on the test sample are 1.28 degrees in PA and 0.41 arcseconds in separation. The obtained error values seem to be good enough to consider that measuring doubles down to 5 arcseconds with this equipment provides enough precision of the data.

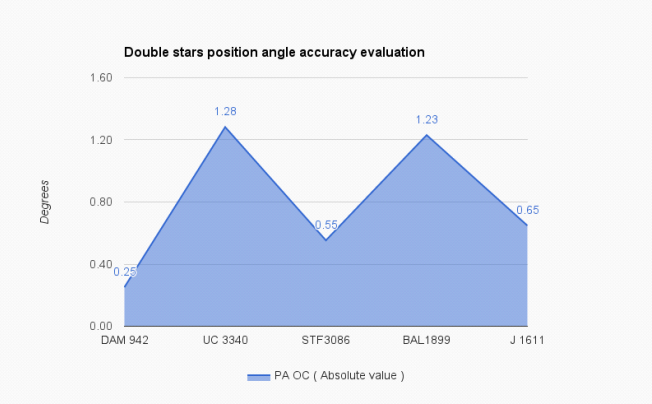

Figure 1. Position Angle differences for five selected comparison objects

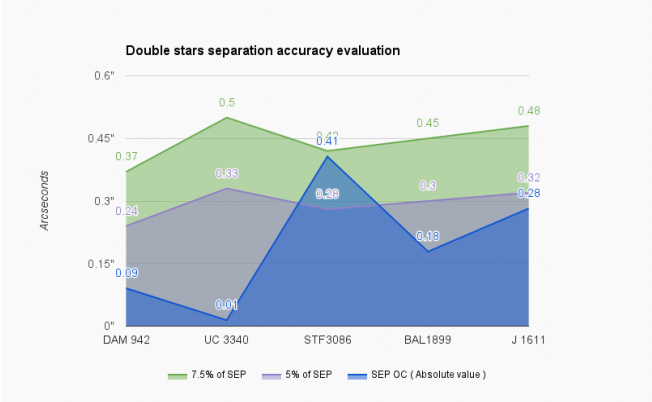

Figure 2. Separation differences for five selected comparision objects

The Measurements

In the next tables, I present the obtained measurements. Please note that all the magnitudes presented are taken from WDS and not measured on images.

Neglected Measurements

In Table 2 I present a list of neglected double stars measured with the described methods.

Missing and erroneous objects:

As in almost any neglected doubles hunt, I found pretty much objects with different issues which can not be measured for various reasons. I will list them here with my notes:

- Objects where the main star is on precise position but no secondary candidate can be identified: **BAR44 , LDS 9104, POU 5843, LDS 6054, SCA 122, BU 1124 AB,POU 310**
- Objects where even the main star can not be identified in the precise position neither in neighborhood: **LDS 6123, LDS 5336, LDS 2959, SCA 145, HDO 158**
- The secondary not found on my images, but close to expected position there is a very faint star barely visible in survey images with Aladin software[3]. Clearly the secondary is much weaker than catalog and also weaker than my magnitude limit (16) : **POU 635 , LDS1174 AC, HL 24, SLE349 AC**
- There is no object on the position. But there is an object that is matching closely by separation and PA in the neighborhood. Still the secondary star is much more fainter than the catalog value and it drops under the magnitude limit of my image (16) . The pair was identified with Aladin but I'm unable to precisely measure it on my image due to the presented reasons. The correct position of the main star is 23 52 26.998 +24 17 26.59 I presume having last measurements for more than 100 years is plausible that the precise position has a little shift: **POU 5868**
- Main star found . A secondary found at 77 arcsec instead of 18. Having the last observations older than one century some typo is not impossible if we consider 77/78 arcseconds are 1 minute and 17/18 arcseconds or even more simply 7 could be mistaken with 1. The difference on PA is 10 degrees which is not completely not plausible **BAL 2539** with my determinations at JD 2457570.5 being : PA=91.89718 and SEP=77.02532

Other Double Stars Measurements

In Table 3 I present a list of double stars measured with the described methods. These stars were not intentionally targeted. They were on the same FITS with at least one of the targeted objects, so it could be measured with minimal effort.

Acknowledgements

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

Data reduction was carried out using the Astrometrica software developed and maintained by Herbert Raab.

This research made use of the Aladin Sky Atlas developed at CDS, Strasbourg Observatory, France.

Table 2. Measured Neglected Double Stars

Name	RA+Dec	Mags	PA	Sep	Date	N	Notes
JSP 423	10430-5951	9.9; 10.7	270.5	2.24	2015.084	1	1
J 1200	18052+0645	12.4; 16.4	207.7	5.23	2016.499	1	
SLE 156	18209+0930	10.9; 11.3	340.7	87.49	2016.499	1	2
J 104AB	18435-0817	10.1; 13.8	98.2	14.61	2016.499	1	
KUI 87AD	18435-0817	10.1; 15.1	308.6	16.05	2016.499	1	
HO 115AB	19549+1715	11.7; 13.6	351.8	5.92	2016.499	1	
BEW 5	16561+0125	10.4; 13.7	187.4	9.69	2016.499	1	3
BU 1371AB	02193-0259	10.2; 13.7	69.0	73.56	2016.750	1	
BAL2922	18146+0422	12.0; 14.3	75.7	60.82	2016.499	1	
RST4268	05096-0356	11.1; 15.2	228.8	6.83	2016.846	1	

NOTES

1. This double is under my accuracy test limits so I can not guarantee for high accuracy in the measured values but since I had it in a field and I could identify it I decided to measure it because the object is neglected and not measured from 1964.
2. This is a strange object. There is no 10 arcsec double in the field. But there is one 1 minute separated double which have close magnitudes with the targeted one and a perfectly matching PA. More strangely the precise coordinates seems to point to the secondary from this pair. I presume the separation from catalog is wrong (all other stuff seems to match). In my determination the correct precise coordinates seems to be 18 20 57.477+09 28 32.89.
3. Main star precise coordinates seems a little wrong. In my determination the coordinates are 16 56 05.600 01 25 13.68

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Table 3. Other Double Stars Found in Analyzed Images

Name	RA+Dec	Mags	PA	Sep	Date	N	Notes
H6 2AC	18006+0256	9.4; 11.2	142.2	55.07	2016.499	1	
BU 634CD	18006+0256	11.2; 13.9	120.0	6.24	2016.499	1	
BU 634AE	18006+0256	9.4; 13.7	179.7	45.12	2016.499	1	
SLE 349AB	18310+0648	12.4; 13.4	355.2	20.81	2016.499	1	
J 1372	18318+0641	13.8; 12.8	118.3	5.19	2016.499	1	
J 104AC	18435-0817	10.1; 13.7	195.4	39.30	2016.499	1	
SLE 237AF	18435-0817	10.1; 11.8	142.6	78.93	2016.499	1	
SLE 238	18441-0817	12.1; 11.5	67.7	11.68	2016.499	1	
SLE 236	18434-0814	12.1; 12.4	294.8	10.60	2016.499	1	
BRT 483	18425-0807	14.3; 13.2	48.8	4.08	2016.499	1	
HO 115AC	19549+1715	11.7; 12.4	84.5	49.15	2016.499	1	
BAL1560	20281+0140	11.7; 14.7	3.3	6.56	2016.499	1	
POU5840	23397+2359	10.5; 12.7	175.4	19.82	2016.698	1	
HJ 291	22050+1128	12.9; 12.1	264.4	8.67	2016.698	1	1
HJ 290A		13.4; 13.8	281.4	12.15	2016.698	1	2
SCA 149	23151+0348	10.4; 10.9	19.7	65.86	2016.698	1	
BAL 948	00531+0100	13.0; 13.5	53.3	8.02	2016.750	1	
H6 1AC	02193-0259	10.2; 10.3	68.3	123.80	2016.750	1	
STG 1AD	02193-0259	10.2; 13.1	324.2	165.57	2016.750	1	
H6 1BC	02193-0259	13.7; 10.3	67.2	50.26	2016.750	1	
HL 32AC	03497+2343	8.6; 12.7	201.7	117.07	2016.846	1	
HL 27AB	03489+2351	8.7; 14.8	241.9	78.68	2016.846	1	
POU 649	05182+2411	16.1; 14.6	90.7	10.18	2016.846	1	3
POU 659	05194+2433	11.8; 14.1	124.4	16.47	2016.846	1	
POU 387	04056+2330	11.7; 13.0	215.8	8.78	2016.898	1	
POU 385	04053+2337	11.1; 14.0	7.8	16.68	2016.898	1	

Table Notes:

1. The main component as indicated by the coordinates seems to be the fainter star from the combination. Still the other measurements indicated as the brightest. The difference is not big. I presume there was a mistake in deciding the primary or the magnitudes has changed in time (maybe one of the stars from the pair is variable)
2. This object is missing in the last WDS catalogue. Still it is present in the old versions at the precise position but with brighter magnitudes (I have magnitudes of 13.4 / 13.8 instead of 10/10.8 in the catalogue) and also the PA seems shifted with 180 (probably a quadrant computation error in the original observation)
3. Primary star weaker than secondary and weaker than catalog value. Secondary magnitude close to catatog magnitude

References

[1] Mason, D.B., Wycoff G.L., Hartkopf, W.I. Washington Double Star Catalog, USNO, 2015, http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/wds/WDS.

[2] Herbert Raab, Astrometrica software, http://www.astrometrica.at/.

[3] Aladin Sky Atlas software, http://aladin.u-strasbg.fr/.

[4] WDS Filter webtool, http://brasov.astroclubul.org/wdsfilter/.

[5] Lucian Curelaru, Ovidiu Tercu, Alexandru Dumitriu, Valentin Gavrila, Felician Ursache, Catalin Vladu, "Neglected Double Star Measurements at the Astronomical Observatory of the Natural Science Museum Galati", *Journal of Double Star Observations*, **8** (3), 201-209, 2012.

[6] UCAC Catalogue, http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/ucac.

[7] Astrometry.net, http://www.astrometry.net.