Photometry of Faint and Wide Doubles in Sagitta

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Abstract: Images of several double stars in Sagitta published on the "Double Star Imaging Project" Yahoo Group page suggest magnitude issues compared with the corresponding WDS catalog data per April 2015. Taking additional images with V-filter enabled photometry for these pairs, provided confirming results.

Introduction

This paper identifies double star systems in Sagitta that appear to have visual magnitudes that are in conflict with the data as published in the WDS. During the course of a long term project to image double stars accessible to backyard telescopes while employing a consistent imaging regime, from one location, the sheer volume of images has allowed the authors to identify with some certainty double star systems having component magnitudes that are clearly in conflict with the published data. After visually identifying these suspect systems, the authors consult the University of Strasburg's website, VizieR, to access the online digital sky survey catalogues to confirm the visual observations. The preliminary findings are listed below.

HO 442 – WDS 19080+1910. Listed magnitudes of 12.19 & 12.70. First impressions are that both the A & B components are brighter, possibly 11.4 & 12.3. UCAC4 provides for A, an fmag. of 11.399 and Vmag. of 11.281. For B we have only the fmag. at 12.29.

HO 570 – WDS 19087+1914. Listed magnitudes of 10.9 & 15.63. The image clearly shows the B component. At 15.63 we would expect to see nothing. The 10.9 mag. value for A appears reasonable and we estimate the magnitude of B to be 11.9. UCAC4 fmags for A & B are 10.552 and 12.074. Vmag for A is 10.741, no value for B.

J 2947 – WDS 19100+1744. Listed magnitudes of 12.5 & 12.5. With every great theory there exists an anomaly. In this case the image did reveal this faint system so the assumption, based on the limiting magnitude of the imaging system of magnitude 12.0, was that this system was brighter than the listed magnitudes, possibly in the mag 11.8 range. The UCAC4 fmag. values (no Vmag values available) are 13.269 and 13.468, which surprised us.

J 1303 - WDS 19157+1654. Listed magnitudes of 9.8, 10.3. During image acquisition, stars of this magnitude should have been readily visible at the eyepiece. Normal exposure durations should have easily captured this pair. It was only after longer exposures and increased ISO settings that this pair was captured. Estimated magnitudes were in the mag 12.3 range, stars being similarly dim. UCAC4 fmags for A & B components are 12.350 & 12.578. Vmag for A is 12.086, no value for B.

L 45 – WDS 19319+1804. Listed magnitudes of 10 & 11. Again, at these magnitudes, the system was not visible at the eyepiece. First impressions are that the

Table 1: WDS April 2015 values for the objects

ID	Name			RA	Dec	Sep	PA	M1	M2
WDS19080+1910	HO 442	AB	Sge	19:07:57.061	+19:10:12.399	4.0	123	12.19	12.70
WDS19087+1914	HO 570	AB	Sge	19:07:45.807	+19:09:39.302	10.2	228	10.90	15.63
WDS19100+1744	J 2947	AB	Sge	19:10:02.071	+17:44:18.801	5.7	40	12.50	12.50
WDS19319+1804	L 45	AB	Sge	19:31:52.761	+18:04:02.901	4.9	146	10.00	11.00
WDS19459+1832	OL 74	AB	Sge	19:45:49.541	+18:36:47.703	4.9	180	9.50	9.60
WDS19468+1839	OL 72	AB	Sge	19:46:42.317	+18:38:49.699	6.6	9	10.52	10.50
WDS19477+1836	J 827	AB	Sge	19:47:38.251	+18:35:26.397	3.2	35	10.50	13.00
WDS19500+1702	J 1107	CD	Sge	19:50:00.641	+17:02:32.497	3.1	197	11.30	11.90
WDS20096+1648	STF2634	AB	Sge	20:09:34.297	+16:48:19.203	4.1	14	7.77	9.92

components have very similar magnitudes. Stars are barely resolved in the image, indicating magnitudes are closer to 12.0. UCAC4 fmags. are 12.578 & 12.771. Vmag for A is 12.402, no value for B.

OL 74 – WDS 19459+1832. Listed magnitudes are 9.5 & 9.6. It is fairly obvious something is wrong here. Normal imaging protocol produced nothing but the smallest hint of the system on the image indicates that stellar magnitudes were indeed beyond 12.0. Similarly, at the listed magnitudes, we should have had no problem observing this pair at the eyepiece. UCAC4 provides fmags values for A & B of 12.871 and 12.888.

OL 72 – WDS 19468+1839. Listed magnitudes of 10.52 & 10.5. First impressions were that the component magnitudes were brighter than the records, possibly in the 10.2 range. Both stars looked very equal. UCAC4 provides fmag. values for A & B of 10.123 & 10.167. Vmags are 9.992 and 9.992.

J 827 – WDS 19477+1836. Listed magnitudes of 10.5 & 13 @ 3.2“ separation. Again, normal imaging protocols produced only the smallest hint of this pair. The A mag. of 10.5 is clearly suspect while the magnitude of the companion appeared plausible at 13. UCAC4 provides values for the A component only; fmag. 11.589 and Vmag. 11.553. Nomad1 provides a Vmag. for “A” of 11.605.

J 1107CD – WDS 19500+1702. Listed magnitudes of 11.3 & 11.9. Another anomaly that has been experienced is the slight but noticeable increase in stellar magnitude that is being experienced with imaging closer to the zenith. Estimated magnitudes are 11.9 and 12.3 It is becoming apparent that our equipment is reaching deeper. We are also noticing, as the components get dimmer, the previous separation limits have decreased. The typical 5.0 arc-second limit has been reduced to the 3.0” to 3.5” range as experienced with J 1107CD having a recorded separation of 3.1”. UCAC4 fmags for (C,D) are 12.415 & 12.683. Vmag, no values.

STF 2634AB – WDS 20096+1648. Listed magnitudes of 7.77 & 9.92. The image is suggesting that both components are dimmer. Estimates are 8.5 and 10.5. Not only is the image brightness less than the data, the compact separation of 4.10” would typically not allow the separation of stars with these brighter magnitudes. UCAC4 “A” values are fmag. 8.84 & Vmag. 8.397. NOMAD 1 has a Vmag for “A” as 7.688. There are no values for B in either catalog.

Further Research

To investigate further our initial findings, we concluded that the best approach would be to obtain new images suitable for photometry. These images were taken with an online 610mm f/6.5 CDK telescope having a resolution of 0.625 arcseconds per pixel and equipped with a V-filter, located in Auberry, California. Initial plate solving and stacking of 5 images each was done with AAVSO VPhot, and plate solving of the stacked image was then repeated with Astrometrica with UCAC4 as reference star catalog. Photometry was completed with Astrometrica. Only reference stars 10.5mag to 14.5mag were used to be most precise in this magnitude range, thus results for stars significantly brighter are less reliable than the results for star in the indicated magnitude range. The new values are included in Table 2. M+ is new measurement, Err = error estimation calculated as

$$\sqrt{dV_{mag}{}^2 + (2.5\log(1+1/SNR))^2}$$

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Table 2. Photometry results based on iTelescope iT24 images used with Astrometrica. In case of J827 also astrometry calculations for Sep and PA have been done based on the formulae provided by Buchheim (2008).

ID	Name		M1+	Err1	M2+	Err2	Date	Notes
WDS19080+1910	HO 442	AB	11.529	0.07	12.722	0.07	2015.678	
WDS19087+1914	HO 570	AB	10.805	0.08	12.488	0.08	2015.678	
WDS19100+1744	J 2947	AB	13.462	0.11	13.550	0.11	2015.678	
WDS19319+1804	L 45	AB	13.104	0.05	13.157	0.05	2015.678	
WDS19459+1832	OL 74	AB	12.888	0.09	14.091	0.10	2015.678	
WDS19468+1839	OL 72	AB	10.530	0.11	10.611	0.11	2015.678	
WDS19477+1836	J 827	AB	11.694	0.11	12.829	0.11	2015.678	1)
WDS19500+1702	J 1107	CD	12.753	0.13	13.516	0.13	2015.678	
WDS20096+1648	STF2634	AB	7.633	0.08	9.659	0.08	2015.678	2)

Notes:

1. Astrometry results: dRA 0.14, dDec 0.14. RA/Dec for A: 19 47 38.247/+18 35 26.37 and B: 19 47 38.362/+18 35 28.72 giving Sep=2.863 with Err=0.198 and PA=34.828 with Err =3.956
2. Overlapping star disks. A and B too bright for reliable measurement.

where *SNR* = Signal to noise ratio and *dVmag* = average Vmag error over all used reference stars (SNR and *dVmag* not listed due to space restrictions). Number of observations is 5 for all objects. Date given is the Bessel epoch of the observation.

Summary of Present Data vs. New Photometry

With few exceptions the photometry results confirmed the image based first impressions at least to some degree. In Table 3 (next page) we give a summary per object.

Acknowledgements

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

- Washington Double Star Catalog
- iTelescope
- AAVSO VPhot
- AAVSO APASS
- UCAC4 catalog via the University of Heidelberg website and directly from USNO DVD
- Aladin Sky Atlas v8.0
- SIMBAD, VizieR
- 2MASS All Sky Catalog
- AstroPlanner v2.2
- MaxIm DL6 v6.08
- Astrometrica v4.8.2.405

References

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

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Table 3. Summary of results compared to WDS. With a few exceptions, WDS data changes are as suggested.

ID	Name	Notes
WDS19080+1910	HO 442	A: 12.19 B: 12.70 , A: 11.529 B: 12.722 Initial image suggested that both components were brighter than the listed data. New photometry for B supports the existing data as correct. Therefore, only the primary need be considered for correction
WDS19087+1914	HO 570	A: 10.90 B: 15.63 , A: 10.805 B: 12.488 New photometry confirms the existing data for the primary as correct and clearly suggests a revision for the secondary
WDS19100+1744	J 2947	A: 12.50 B: 12.50 , A: 13.462 B: 13.550 Estimates based on the original image suggested the magnitudes for both components were brighter than the WDS data. New photometry clearly indicates that magnitudes are in fact substantially dimmer than the listed WDS data and very much in keeping with the fmag values from the UCAC4 of 13.269 and 13.468 respectively. This raises the question as to why did the image suggest components to be brighter – may be a star color issue. In conclusion, the new photometry is suggesting a correction to the WDS data
WDS19319+1804	L 45	A: 10 B: 11 , A: 13.104 B: 13.157 First impressions suggested that both components have very similar magnitudes and that these magnitudes are significantly dimmer than the present WDS data. New photometry confirms that the magnitudes for both components are indeed dimmer than the existing data and supports the visual estimate that both components are very similar in brightness
WDS19459+1832	OL 74	A: 9.5 B: 9.5 , A: 12.888 B: 14.091 Both components on the original image were barely visible suggesting much dimmer than mag 12. New photometry clearly supports the initial findings and indicates a significant Δm. A change to the WDS data is recommended
WDS19468+1839	OL 72	A: 10.52 B: 10.50 , A: 10.530 B: 10.611 First impressions suggested that both components were brighter than the WDS data. The new photometry supports the existing WDS records
WDS19477+1836	J 827	A: 10.5 B: 13 , A: 11.694 B: 12.829 Review of the initial image suggested the primary is substantially dimmer than the WDS record. The secondary at 13mag seemed reasonable. New photometry supports the initial observation and suggests a correction to the magnitude at least of the primary
WDS19500+1702	J 1107	C: 11.3 D: 11.9 , A: 12.753 B: 13.516 The initial image suggested that both the primary and secondary were significantly dimmer than the WDS data. New photometry supports these findings. Therefore a revision to the data is suggested
WDS20096+1648	STF2634	A: 7.77 B: 9.92 , A: 7.638 B: 9.659 Initial review of the image suggested that both components were dimmer than the listed data. Much of this was based on having relatively clean resolved components despite the rather small separation of 4.1 arc-seconds. Previous experience has shown that images with primary stars in the 7.7mag range do not show close companions so cleanly. But photometry suggests existing WDS data as confirmed