Measurements of Some SKF Objects

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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

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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

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

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

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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 40.748	-38 40 22.39	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 40.735	-38 40 30.09							11.000	0.051	114.50				
SKF1893	A	10 27 47.638	-34 23 58.63	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 50.263	-34 23 52.58							13.089	0.073	54.04				
SKF 792	A	09 49 56.461	-34 06 58.11	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 56.088	-34 06 45.58							11.144	0.100	122.75				
SKF1890	A	10 11 56.503	-38 08 34.65	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 58.844	-38 08 31.78							10.977	0.080	134.18				
SKF1886	A	09 31 34.396	-34 01 56.52	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 28.830	-34 03 36.72							11.843	0.061	100.60				
SKF1919	A	12 34 07.750	-30 45 23.75	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	12 34 08.538	-30 45 26.19							13.960	0.083	23.68				
SKF1914	A	12 08 40.719	-28 04 18.67	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 39.307	-28 04 20.08							10.807	0.060	152.32				
SKF1840	A	09 08 20.270	05 08 39.29	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	09 08 20.874	05 08 21.07							13.140	0.043	63.59				
SKF2116	B	12 18 29.920	-33 30 31.96	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 29.846	-33 30 37.74							13.837	0.072	26.51				
SKF1470	A	10 47 44.916	-24 11 26.59	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 44.782	-24 11 24.01							14.126	0.058	35.28				
SKF1923	AB	12 37 42.341	-27 08 20.74	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 33.226	-27 08 17.94							13.249	0.093	45.11				
SKF1920	A	12 34 23.710	-27 00 04.17	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 22.954	-27 00 07.67							12.871	0.092	60.54				

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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 .

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- 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

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