

Physical Double Stars in the SLoWPoKES Catalogs

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Abstract: The ongoing research on binaries is lately supported by very comprehensive and precise new catalogs like SLoWPoKES (Sloan Low-mass Wide Pairs of Kinematically Equivalent Stars). This report counter-checks the claim that all objects in this catalog should be physical double stars by testing a small, randomly selected sample of objects for potential common proper motion.

Introduction

SLoWPoKES (Sloan Low-mass Wide Pairs of Kinematically Equivalent Stars) consists of two catalogs: SLoWPoKES I (Dhital et al. 2010) with about 1,350 faint binaries found in the Sloan Digital Sky Survey by using proper motion data and SLoWPoKES II (Dhital et al. 2015) with about 100,000 moderately wide binaries with angular separation found in the Sloan Digital Sky Survey results without using proper motion data.

SLoWPoKES I

About 10% of the SLoWPoKES I objects were already listed in the WDS catalog with other discoverer IDs and the rest of the SLoWPoKES I pairs has been added to the WDS catalog with discoverer ID “SLW” and code “VR” for being probably physically related with magnitudes in the red band. I selected a few of the brighter pairs in the ~ 15 mag range for a counter-check of the validity of the SLoWPoKES I evaluation process. The results are given in Table 1.

Seven out of 11 randomly selected objects are within the “allowed” error range for similar proper motion vector direction and speed and can be considered as solid CPM objects even if PM error size and relation separation/speed are outside the range considered as necessary for a perfect AAAA-rating.

One object (SLW 0856+09) seems in terms of common proper motion completely off – this is most probably not a binary. To counter-counter-check I relied not only on the 2MASS to GAIA position comparison but had also a look at SDSS7 and SDSS9 positions giving the same negative result.

Two objects out of 11 show a difference in proper

motion direction giving room for second thoughts that these might really be good CPM candidates.

And finally, object SLW 1332-03 shows some difference in proper motion vector length – for closer pairs often a hint for a potential orbit but certainly not for such a wide pair, so again there is some room for second thoughts if this is really such a good CPM candidate.

SLoWPoKES II

This catalog consists of more than 100,000 objects found in the Sloan Digital Sky Survey in the following way: "The candidate pairs are vetted by comparing the stellar density at their respective Galactic positions to Monte Carlo realizations of a simulated Milky Way" (quote from the VizieR catalog description). The concept for this approach was already presented in Dhital et. al 2013, but in the final release (Dhital et al. 2015), the adopted 14% error range in the given photometric distances gives room for second thoughts and is reason enough to counter-check these pairs with proper motion values derived from the comparison of SDSS (and if available other catalogs) to GAIA DR1 positions. The results for a few brighter but randomly selected SLoWPoKES II objects are given in Table 2.

The results in Table 2 show that only 2 out of 16 selected objects are already listed as WDS catalog objects even if the selected objects were rather relatively bright compared with the average brightness of the SLoWPoKES II catalog objects – so in total the overlap between SLoWPoKES II and WDS seems to be quite small. And also only 3 out of 16 (one of them also

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Physical Double Stars in the SLoWPoKES Catalogs

Table 1: CPM Rating for the selected SLoWPoKES I objects

Description of the table contents
 - Header Line: Gives the WDS catalog data of the selected object with Date = last observation and SLW and WDS ID in the Notes column
 - Data Lines:
 -- RA and Dec are coordinates in decimal degrees format for the catalogs indicated in the Source column as these values are directly usable for calculating Sep and PA
 -- Sep gives separation in arcseconds calculated as $\sqrt{((RA2-RA1) \cdot \cos(Dec1))^2 + (Dec2-Dec1)^2}$ in radians (Buchheim 2008)
 -- PA gives position angle in degrees calculated as $\arctan((RA2-RA1) \cdot \cos(Dec1) / (Dec2-Dec1))$ in radians depending on quadrant (Buchheim 2008)
 -- M1 and M2 give Gmags in the GAIA DRI lines and estimated Vmags in the 2MASS (calculated from J- and K-band) and SDSS (gmag/2+rmag/2) lines
 -- pmRA1 and pmDec1 with e_pm1 give the proper motion data for A and pmRA2, pmDec2 and e_pm2 for B in the GAIA DRI line Calculated by position comparison with 2MASS and SDSS
 -- Ap indicates the aperture used (calculated circular surface diameter for GAIA)
 -- Me indicates the WDS code for the used observation method
 -- Date is the observation epoch
 -- CPM Rat gives in the GAIA DRI line the rating of the CPM assessment based on comparison of the given PM data (description in the appendix)
 -- Source/Notes finally indicates the used catalog and additional comments and explanations if considered necessary

Name	RA	Dec	Sep	PA	M1	M2	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
SLW 1	00:02:03.74	+29:28:30.5	16.70	192.0	16.80	19.40	198	38		197	35				2010		SLW 0002+29, WDS00021+2929, WDS notes code VR.
	0.51553600	29.4751320	16.79	191.4	16.23	17.96							1.30	E2	1998.755		2MASS, M1 and M2 estimated from J- and K-band
	0.51655752	29.4752976	16.78	191.6	16.34	18.48	197.07	36.70	6.16	194.89	38.10	7.41	0.96	Hg	2015	AARB	GAIA DRI, M1 and M2 are G-band, PM data calculated from position comparison with 2MASS
																	Solid CPM candidate
SLW 753	12:39:51.83	+01:00:08.3	20.10	352.0	13.84	15.90	-53	-13		-56	1				2010		SLW 1239+01, WDS12399+0100, WDS notes code VR.
	189.965959	1.00235	20.03	352.2	14.18	16.29							1.30	E2	2000.171		2MASS, M1 and M2 estimated from J- and K-band
	189.96576817	1.0022744	20.07	352.2	13.79	15.79	-46.32	-18.35	7.29	-47.88	-16.27	7.29	0.96	Hg	2015	AACH	GAIA DRI, M1 and M2 are G-band, PM data calculated from position comparison with 2MASS
																	Solid CPM candidate

Table 1 continues on next page.

Physical Double Stars in the SLoWPoKES Catalogs

Table 1 (continued). CPM Rating for the Selected SLoWPoKES I Objects

Name	RA	Dec	Sep	PA	M1	M2	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
SLW 314	08:56:37.16	+09:01:28.9	87.20	327.0	13.90	16.90	-30	-4		-44	13				2003		SLW 0856+09. WDS08566+0901. WDS notes code VR.
	134.154921	9.024697	87.03	326.9	14.12	17.28							1.30	E2	2000.184		2MASS. M1 and M2 esti- mated from J- and K-band
	134.154827	9.024696	87.17	326.9		17.52							2.50	Es	2003.242		SDSS DR7. Vmags estimat- ed from (gmag+rmag)/2
	134.154804	9.02467	87.21	326.9		17.52							2.50	Es	2004.075		SDSS DR9. Vmags estimat- ed from (gmag+rmag)/2
	134.15472781	9.0246620	87.28	326.9	13.86	16.76	-46.36	-8.52	6.22	-58.60	3.16	7.70	0.96	Hg	2015	CCCC	GAIA DR1. M1 and M2 are G-band. PM data calculat- ed from position compar- ison with 2MASS
	134.15472781	9.0246620	87.28	326.9	13.86	16.76	-29.99	-10.42	4.69	-33.63	-1.53	4.71	0.96	Hg	2015	CCCC	GAIA DR1. M1 and M2 are G-band. PM data calculat- ed from position compar- ison with SDSS DR7
	134.15472781	9.0246620	87.28	326.9	13.86	16.76	-24.79	-2.65	5.96	-34.24	-0.99	0.51	0.96	Hg	2015	BCCC	GAIA DR1. M1 and M2 are G-band. PM data calculat- ed from position compar- ison with SDSS DR9
																	Most probably no CPM pair but optical
SLW 619	11:36:29.74	+01:20:04.2	19.00	265.0	13.95	16.72	-40	-2		-40	-3				2010		SLW 1136+01. WDS11365+0120. WDS notes code VR.
	174.123841	1.33441	18.91	265.0	14.34	16.49							1.30	E2	2000.176		2MASS. M1 and M2 esti- mated from J- and K-band
	174.123931	1.334512	18.97	265.0	14.50	17.42							2.50	Es	2000.343		SDSS DR7. Vmags estimat- ed from (gmag+rmag)/2
	174.123927	1.334519	18.97	265.0	14.50	17.42							2.50	Es	2000.343		SDSS DR9. Vmags estimat- ed from (gmag+rmag)/2
	174.12376618	1.3345065	18.95	265.0	13.84	16.21	-18.16	23.44	16.22	-20.59	22.45	16.22	0.96	Hg	2015	BACC	GAIA DR1. M1 and M2 are G-band. PM data calculat- ed from position compar- ison with 2MASS
	174.12376618	1.3345065	18.95	265.0	13.84	16.21	-40.47	-1.34	4.25	-39.24	-1.85	4.28	0.96	Hg	2015	BCCB	GAIA DR1. M1 and M2 are G-band. PM data calculat- ed from position compar- ison with SDSS DR7
	174.12376618	1.3345065	18.95	265.0	13.84	16.21	-39.49	-3.06	0.02	-38.26	-3.57	0.52	0.96	Hg	2015	BCAB	GAIA DR1. M1 and M2 are G-band. PM data calculat- ed from position compar- ison with SDSS DR9. Suspect SDSS9 position error for A: 0.000 arcseconds
																	Very weak CPM candidate

Table 1 continues on next page.

Physical Double Stars in the SLoWPoKES Catalogs

Table 1 (continued). CPM Rating for the Selected SLoWPoKES I Objects

Name	RA	Dec	Sep	PA	M1	M2	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
SLW 213	07:56:14.32	-10:51:42.900	11.90	319.0	14.30	14.70	-53	-39		-56	-26				2010		SLW 0756-10. WDS07562-1052. WDS notes code VR.
	119.059875	-10.861798	11.90	318.9	14.60	14.97							1.30	E2	1999.039		2MASS. M1 and M2 estimated from J- and K-band
	119.05964237	-10.8619740	11.92	319.0	14.20	14.72	-51.53	-39.70	5.32	-52.15	-38.34	5.32	0.96	Hg	2015	AABB	GAIA DR1. M1 and M2 are G-band. PM data calculated from position comparison with 2MASS
																	Solid CPM candidate
SLW 480	10:30:07.85	+13:16:24.6	16.80	197.0	14.28	16.46	-34	31		-32	32				2010		SLW 1030+13. WDS1030+1316. WDS notes code VR.
	157.532751	13.273484	16.80	196.5	14.63	16.79							1.30	E2	1997.929		2MASS. M1 and M2 estimated from J- and K-band
	157.53256655	13.2736437	16.81	196.4	14.23	16.23	-37.86	33.68	5.40	-37.70	33.20	5.40	0.96	Hg	2015	AAAC	GAIA DR1. M1 and M2 are G-band. PM data calculated from position comparison with 2MASS
																	Solid CPM candidate
SLW 888	13:32:17.53	-03:02:20.1	57.30	349.0	14.29	15.76	-38	19		-38	22				2001		SLW 1332-03. WDS13323-0302. WDS notes code VR.
	203.073072	-3.038894	57.35	348.5	14.59	15.89							1.30	E2	1999.108		2MASS. M1 and M2 estimated from J- and K-band
	203.07290692	-3.0388434	57.33	348.6	14.26	15.64	-37.34	11.47	5.80	-34.64	10.28	5.80	0.96	Hg	2015	ABCC	GAIA DR1. M1 and M2 are G-band. PM data calculated from position comparison with 2MASS
																	Good CPM candidate
SLW 28	00:31:57.51	+25:09:26.1	38.10	229.0	14.60	16.30	-5	-49		0	-48				2014		SLW 0031+25. WDS00320+2509. WDS notes code VR.
	7.989661	25.157267	38.25	229.1	15.05	16.02							1.30	E2	1997.810		2MASS. M1 and M2 estimated from J- and K-band
	7.98964250	25.1570384	38.22	229.1	14.51	15.89	-3.51	-47.89	5.36	-2.65	-45.60	5.36	0.96	Hg	2015	AAAC	GAIA DR1. M1 and M2 are G-band. PM data calculated from position comparison with 2MASS
																	Solid CPM candidate
SLW 152	03:20:11.69	+77:58:28.7	28.50	330.0	14.60	15.80	33	-95		31	-100				2005		SLW 0320+77. WDS03202+7758. WDS notes code VR.
	50.048513	77.974884	28.55	330.0	13.58	14.46							1.30	E2	2000.751		2MASS. M1 and M2 estimated from J- and K-band
	50.04904943	77.9744707	28.64	329.9	13.97	14.90	28.24	-104.41	9.75	21.60	-101.03	9.75	0.96	Hg	2015	BABB	GAIA DR1. M1 and M2 are G-band. PM data calculated from position comparison with 2MASS
																	Weak CPM candidate

Table 1 concludes on next page.

Physical Double Stars in the SLoWPoKES Catalogs

Table 1 (conclusion). CPM Rating for the Selected SLoWPoKES I Objects

Name	RA	Dec	Sep	PA	M1	M2	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
SLW 667	11:54:55.49	-01:34:13.5	16.10	55.0	14.64	15.79	44	-16		47	-15				2010		SLW 1154-01. WDS11549-0134. WDS notes code VR.
	178.731203	-1.570382	16.08	55.2	14.93	15.65							1.30	E2	2000.258		2MASS. M1 and M2 estimated from J- and K-band
	178.73138090	-1.5704992	16.11	55.2	14.52	15.58	43.43	-28.62	6.71	45.61	-29.04	6.71	0.96	Hg	2015	AACC	GAIA DR1. M1 and M2 are G-band. PM data calculated from position comparison with 2MASS
																	Solid CPM candidate
SLW 401	09:52:19.92	+37:38:01.2	79.80	352.0	14.70	16.00	-36	-32		-36	-45				2003		SLW 0952+37. WDS09523+3738. WDS notes code VR.
	148.083062	37.633736	79.82	352.3	14.88	16.02							1.30	E2	1998.229		2MASS. M1 and M2 estimated from J- and K-band
	148.08288176	37.6335845	79.84	352.3	14.58	15.63	-30.64	-32.52	5.06	-29.90	-31.41	5.06	0.96	Hg	2015	AACC	GAIA DR1. M1 and M2 are G-band. PM data calculated from position comparison with 2MASS
																	Solid CPM candidate

Physical Double Stars in the SLoWPoKES Catalogs

Table 2. CPM Rating for the Selected SLoWPoKES II Objects

Description of Table 2 contents:

- SLW ID gives the SLoPoKES catalog ID of the selected object in the header line
- RA and Dec give the catalog coordinates of the A component in decimal degrees format as these values are directly usable for calculating Sep and PA
- Sep gives separation in arcseconds calculated from the coordinates of both components as $\sqrt{(\Delta RA)^2 + (\Delta Dec)^2}$ in radians
- PA gives position angle in degrees calculated from the coordinates of both components as $\arctan((\Delta RA) * \cos(Dec)) / (\Delta Dec)$ in radians depending on quadrant
- M1 and M2 give Gmags in the GAIA DR1 line, estimated Vmags in the SDSS line calculated as $(g_{mag} + r_{mag})/2$, estimated Vmags in 2MASS lines based on J- and Kmag values and Vmags in URAT1 lines (if available)
- pmRA1 and pmDE1 with e_pm1 give the proper motion data for A and pmRA2, pmDE2 and e_pm2 for B in the GAIA DR1 line calculated by comparing 2MASS or SDSS7 (if available, else SDSS9) to GAIA DR1 positions
- Ap indicates the aperture used (GAIA DR1 as calculated circular surface diameter)
- Me indicates the WDS code for the used observation method
- Date is the observation epoch
- CPM Rat gives in the GAIA DR1 line the rating of the CPM assessment based on comparison of the given PM data (description see appendix)
- Source/Notes finally indicates additional comments and explanations if considered necessary

SLW ID	RA	Dec	Sep"	PA°	M1	M2	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
0000 +2819	0.131312971	28.32874666	1.924	119.690	16.316	16.322	16.31	0.53	5.03	17.32	0.61	5.03	0.96	Hg	2015.000	ACCB	GAIA DR1/SDSS7, No WDS object. Potential CPM candidate, difference in PM vector length may be hint of orbit
	0.131255	28.328745	1.915	119.879	17.6	17.4							2.50	Es	2003.738		SDSS DR7
0000 +1744	0.148452949	17.74543666	1.58	31.33	17.38	17.94	3.27	4.42	0.58	-3.90	-6.64	0.91	0.96	Hg	2015.000	CCCB	GAIA DR1/SDSS9, No WDS object. Optical pair with PM in very different directions
	0.14844700	17.7454290	1.66	31.41	17.96	19.29							2.50	Es	2008.754		SDSS DR9, No SDSS7 object available
0001 -0658	0.3225966	-6.968817837	2.22	102.71	17.48	17.65	14.81	-8.18	0.70	19.76	0.83	0.82	0.96	Hg	2015.000	CCAB	GAIA DR1/SDSS9, No WDS object. Optical pair with PM in very different directions
	0.32257500	-6.9685060	2.21	104.05	18.02	18.30							2.50	Es	2009.788		SDSS DR9, No SDSS7 object available
0000 +2329	0.033153544	23.48981119	2.09	91.77	15.45	15.91	-8.58	8.58	0.26	-10.16	9.23	0.49	0.96	Hg	2015.000	BCAC	GAIA DR1/SDSS9, No WDS object. Weak CPM candidate
	0.03316900	23.4897970	2.10	91.86	16.66	17.11							2.50	Es	2009.049		SDSS DR9, No SDSS7 object available
0001 +1055	0.446105357	10.92316532	7.83	343.61	14.76	17.11	-16.42	-2.15	0.26	-16.62	-2.25	0.95	0.96	Hg	2015.000	ABAB	GAIA DR1/SDSS9, No WDS object. Solid CPM candidate
	0.446105357	10.92316532	7.83	343.61	14.76	17.11	-1.89	-3.20	12.39	-0.49	-9.80	12.39	0.96	Hg	2015.000	CCCC	GAIA DR1/2MASS - large 2MASS position error, but rather solid optical
	0.4460986	10.9231728	7.820	343.943	15.030		-4.11	-1.51	14.29	1.37	-9.43	14.62	0.20	Eu	2012.962	CCCC	URAT1/2MASS - large 2MASS position error, but rather solid optical
	0.446113	10.923178	7.931	343.665	15.2	17.6							1.30	E2	2000.721		2MASS
	0.44613400	10.9231690	7.83	343.62	15.08	17.79							2.50	Es	2008.836		SDSS DR9, No SDSS7 object available

Table 2 continues on next page.

Physical Double Stars in the SLOWPoKES Catalogs

Table.2 (continued). CPM Rating for the Selected SLOWPoKES II Objects

SLW ID	RA	Dec	Sep"	PA°	M1	M2	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
0001 - 0719	0.498063756	-7.320705201	5.72	81.79	15.10	16.29	12.85	8.84	0.28	13.82	9.47	0.28	0.96	Hg	2015.000	ACAB	GAIA DRI/SDSS9. No WDS object. Good CPM candidate. Difference in PM vector length might indicate an orbit
	0.498063756	-7.320705201	5.72	81.79	15.10	16.29	15.78	-2.26	5.68	15.22	-4.94	5.68	0.96	Hg	2015.000	CACB	GAIA DRI/2MASS - quite different PM result
	0.49804500	-7.3207180	5.71	81.81	15.58	17.12							2.50	Es	2009.788		SDSS DR9. No SDSS7 object available
	0.497992	-7.320695	5.735	81.372	15.6	16.8							1.30	E2	1998.766		2MASS
0002 +0724	0.651225937	7.414281561	8.294	317.553	15.889	17.140	1.90	-17.65	10.61	4.99	-2.12	10.71	0.96	Hg	2015.000	CCCC	GAIA DRI/SDSS7. No WDS object. Optical pair with PM in very different directions
	0.651225937	7.414281561	8.29	317.55	15.89	17.14	-14.53	-6.42	6.46	-3.02	17.55	6.46	0.96	Hg	2015.000	CCCC	GAIA DRI/2MASS. Optical
	0.651221	7.414327	8.208	316.727	16.4	17.9							2.50	Es	2005.734		SDSS DR7
	0.651284	7.414307	8.160	315.080	16.3	17.7							1.30	E2	2000.732		2MASS
0002 - 0643	0.675132066	-6.736861276	16.00	332.57	17.15	17.22	-1.27	4.22	14.52	-5.07	16.51	14.52	0.96	Hg	2015.000	ACCC	GAIA DRI/SDSS7. No WDS object. PM data too small to be significant for CPM, probably optical pair
	0.675132066	-6.736861276	16.00	332.57	17.15	17.22	0.01	-6.05	5.68	-0.60	7.76	5.23	0.96	Hg	2015.000	CCCC	GAIA DRI/2MASS - optical
	0.675135	-6.736871	15.897	332.503	17.8	17.9							2.50	Es	2006.711		SDSS DR7
	0.675132	-6.736834	15.799	332.229	17.7	17.8							1.30	E2	1998.766		2MASS
0002 - 1106	0.743674734	-11.10307957	4.54	235.75	16.26	16.33	16.325	71.27	-8.72	5.41	70.22	-8.73	0.96	Hg	2015.000	ABBB	GAIA DRI/SDSS7. WDS object WDS00030-1106 aka CVR1027 with code "R". Good CPM candidate
	0.743674734	-11.10307957	4.54	235.75	16.26	16.33	69.36	-13.65	5.68	66.48	-16.32	5.68	0.96	Hg	2015.000	AAAB	GAIA DRI/2MASS - solid CPM candidate
	0.743387	-11.103045	4.523	235.645	17.6	17.7							2.50	Es	2000.737		SDSS DR7
	0.743356	-11.103018	4.472	235.872	16.2	16.3							1.30	E2	1998.766		2MASS
0003 - 0504	0.755199682	-5.081447685	2.34	241.91	15.85	15.18	23.22	14.47	16.25	24.00	15.00	16.25	0.96	Hg	2015.000	ACCA	GAIA DRI/SDSS7. No WDS object. Potential CPM candidate with hint of orbit
	0.755146	-5.081481	2.346	241.891	16.5	15.6							2.50	Es	2006.711		SDSS DR7
0003 +0912	0.84692513	9.208370049	6.01	30.44	15.71	16.29	8.15	-42.02	0.34	8.07	-41.90	1.36	0.96	Hg	2015.000	AAAB	GAIA DRI/SDSS9. No WDS object. Solid CPM candidate
	0.84692513	9.208370049	6.01	30.44	15.71	16.29	18.46	-46.92	8.92	21.67	-40.56	8.92	0.96	Hg	2015.000	CBCC	GAIA DRI/2MASS - rather optical
	0.84691100	9.2084420	6.01	30.45	16.63	17.37							2.50	Es	2008.836		SDSS DR9. No SDSS7 object available
	0.846851	9.208556	5.908	30.506	16.0	16.3							1.30	E2	2000.732		2MASS

Table 2 concludes on next page.

Physical Double Stars in the SLOWPoKES Catalogs

Table 2 (conclusion).. CPM Rating for the Selected SLOWPoKES II Objects

SLW ID	RA	Dec	Sep"	PA°	M1	M2	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
0003 +2632	0.905305374	26.53965806	3.89	32.07	16.53	16.91	14.13	-26.21	5.05	14.30	-26.66	5.05	0.96	Hg	2015.000	ABCB	GAIA DRI/SDSS7. WDS object WDS00036+2632 aka CVR1028 with code "R". Good CPM candidate
	0.905305374	26.53965806	3.89	32.07	16.53	16.91	6.42	-31.68	6.66	10.11	-29.33	6.66	0.96	Hg	2015.000	CACB	GAIA DRI/2MASS - PM vector direction too different to be a good CPM candidate
	0.905256	26.53974	3.889	32.008	17.5	18.0							2.50	Es	2003.743		SDSS DR7
	0.905273	26.539801	3.822	31.614	16.8	16.9							1.30	E2	1998.755		2MASS
0001 - 0943	0.477917383	-9.716038367	4.646	236.543	17.499	18.731	121.53	23.39	4.61	121.45	26.30	5.11	0.96	Hg	2015.000	AAAA	GAIA DRI/SDSS7. No WDS object. Listed as VLM Binary candidate in SLOWPoKES-II. Solid CPM candidate
	0.477917383	-9.716038367	4.646	236.543	17.499	18.731	119.64	20.76	6.10	117.39	23.10	5.68	0.96	Hg	2015.000	ABAA	GAIA DRI/2MASS - solid CPM candidate
	0.477429	-9.716131	4.668	236.110	19.9	21.4							2.50	Es	2000.740		SDSS DR7
	0.47737	-9.716132	4.636	235.902	16.5	17.5							1.30	E2	1998.766		2MASS
0000 - 0637	0.014126821	6.617085487			16.286		55.89	28.94	0.31				0.96	Hg	2015.000		GAIA DRI/SDSS9. No WDS object. No object for B in GAIA DRI
	0.013982	6.617011	4.194	28.797	17.3	23.7							2.50	Es	2005.734		SDSS DR9. SDSS9 image suggests either bogus or wrong position - see Figure 1
0000 - 0637													0.96	Hg	2015.000		SDSS9. No resolution of A and B in GAIA DRI
	4.595181	-0.801517	1.617	88.086	21.0	21.0							2.50	Es	2003.809		SDSS DR9. By random selected objects with same observation epoch from ~10 different data points per component (see Figure 2)
0045 +2424	11.27769909	24.40959018	4.250	209.299	16.026	16.213	-4.44	3.22	10.06	-8.09	-0.12	10.22	0.96	Hg	2015.000	CCCC	GAIA DRI/SDSS7. No WDS object. Listed as sdM+sdM Binary Candidate in SLOWPoKES-II. Optical pair
	11.27769909	24.40959018	4.250	209.299	16.026	16.213	1.74	-1.43	7.01	-1.02	-6.15	7.01	0.96	Hg	2015.000	CCCC	GAIA DRI/2MASS - optical
	11.277713	24.409581	4.202	209.082	17.7	18.0							2.50	Es	2004.729		SDSS DR7
	11.27769	24.409597	4.156	209.277	15.7	15.9							1.30	E2	1997.821		2MASS

Physical Double Stars in the SLoWPoKES Catalogs

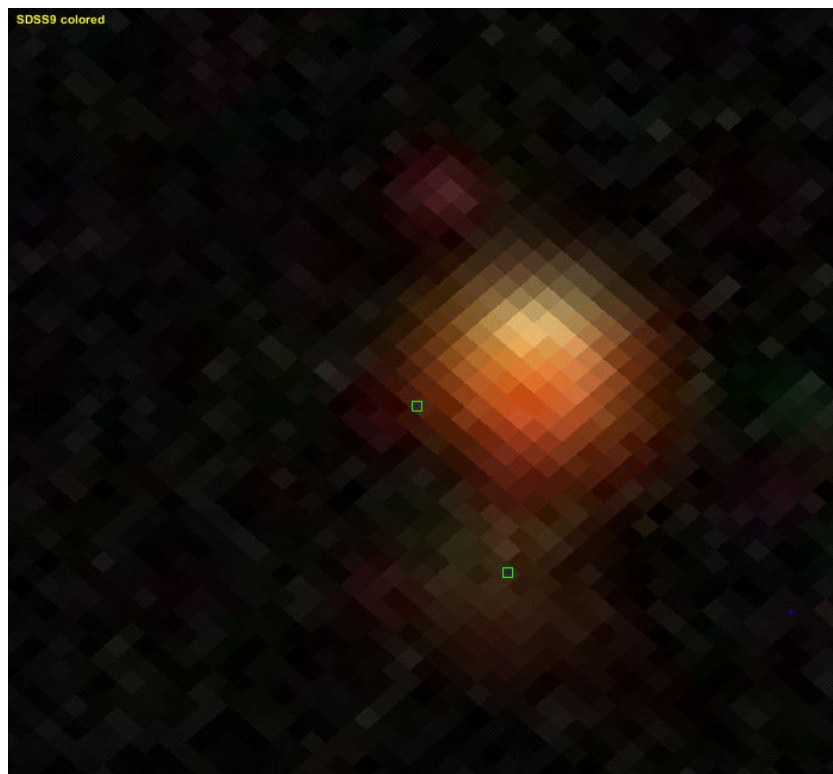


Figure 1: SDSS9 image of SLW0000+0637 with the corresponding SDSS DR9 objects – bogus or wrong position?

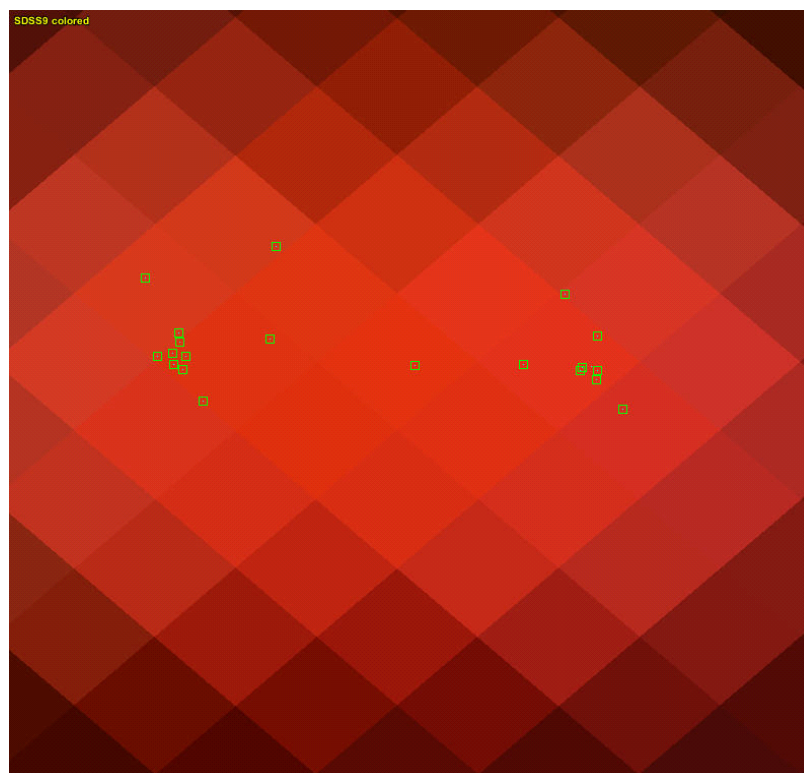


Figure 2: Amazing number of SDSS9 positions for both components of SLW0000-0637

Physical Double Stars in the SLoWPoKES Catalogs

(Continued from page 615)

WDS listed but not V-coded) qualify by comparison of SDSS7 or SDSS9 to GAIA DR1 positions as solid common proper motion pair candidates. The rest seem to be rather optical pairs with one object being probably even bogus so the overall SLoWPoKES II claim to be a binary object catalog is to be taken with some caution. I also got the impression that the SDSS9 positions in rare cases for some objects are not very reliable – jumps in error estimations from 1 mas for one object to over 500 mas for the next object or scatter of ten or more different positions for the same object don't make a trustworthy impression.

In some cases 2MASS and URAT1 data are available, but give a quite different CPM assessment compared to SDSS.

In several cases SLoWPoKES II lists the fainter star as primary – the measurements in Table 2 always show the brighter star as primary which explains the often different PA values.

Another interesting detail is the fact that there seems to be no correlation between the probability for chance alignment (calculated by using a galactic model) and the CPM assessment result as I have assumed that objects with a probability of near zero would be the best performing – and this is by far not the case. In total there is the impression that the proposed probability of false positives less than 5% (Dhital et al. 2015) seems rather optimistic.

I also tried to check a few of the interesting WD+dM candidate systems from Table 5 in Dhital et al., 2015 but found no corresponding GAIA DR1 objects even for the brightest of the listed white dwarfs although objects in the range of 19Gmag should be very well covered by GAIA. At first look, the content of the mentioned Table 5 seems to some degree scrambled as the first object SLW0006+1602 is listed with different parameters in the full data set (with all SLoWPoKES tables merged) – but this was only a chance side effect of some SLW IDs including SLW0006+1602 existing twice.

Summary

The SLoWPoKES I catalog is already included in the WDS catalog with the discoverer ID “SLW” with all objects V-coded for being physical – a critical look at the proper motion data provided by comparison of 2MASS and GAIA DR1 positions confirms that about 2/3 of the objects are solid CPM candidates with some caveats for the rest. As for obvious reasons the probability that the proper motion attributes we are looking for are similar by chance is higher for wide pairs than for close ones may be a more restrictive criterion that should be applied here.

The SLoWPoKES II catalog is a highly interesting source for very faint doubles with a proposed good chance for being physical – but a countercheck with proper motion and parallax data from a future GAIA data release or other sources like UCAC5 or GPS1 seems necessary to come to a final conclusion, at least for a part of the brighter objects. As most SLoWPoKES II objects are very faint, far beyond +20Gmag, so it will take some time to have other than SDSS data sources available for a complete counter-check. The proper motion data gained by comparing SDSS and GAIA DR1 positions do at least for a large part of the checked objects suggest being not solid common proper motion candidates.

As the binaries in this catalog are, as already mentioned, very faint, there is currently only a small overlap with the WDS catalog – if it would make sense to include these more than 100,000 SLoWPoKES II pairs with this large number of probably “only” optical pairs into the WDS catalog is unclear to me, on the other hand it seems realistic to expect about 20,000 objects in this catalog to be solid CPM candidates if very faint ones. Currently (Mar 2017) it is according to Brian Mason (private email) not intended to include SLoWPoKES II into the main WDS catalog but to prepare a WDS supplement that will address SLoWPoKES II.

I contacted also Saurav Dhital as corresponding author of the SLoWPoKES papers for any comments on the findings in this report and got the answer that he is no longer doing astronomy research and his schedule is currently too hectic to read or comment on it within a reasonable time frame.

References:

- Buchheim, Robert, 2008, "CCD Double-Star Measurements at Altimira Observatory in 2007", *Journal of Double Star Observations*, **4**, 27-31.
- Dhital, Saurav, West, Andrew A., Stassun, Keivan G. and Bochanski, John J., 2010, "Sloan Low-Mass Wide Pairs of Kinematically Equivalent Stars (SLoWPoKES): A Catalog of Very Wide, Low-Mass Pairs", *The Astronomical Journal*, **139**, 2566–2586.
- Dhital, Saurav, West, Andrew A., Stassun, Keivan G., Schluns, Kyle J. and Massey, Angela P., 2013, "The SLoWPoKES Catalog of Low-mass Ultra-wide Binaries: A Cool Stars Resource for Testing Fundamental Properties and for Constraining Binary Formation Theory", *Astronomische Nachrichten*, **344**, 14-17.
- Dhital, Saurav, West, Andrew A., Stassun, Keivan G., Schluns, Kyle J. and Massey, Angela P., 2015,

Physical Double Stars in the SLoWPoKES Catalogs

"SLoWPoKES-II: 100,000 Wide Binaries Identified in SDSS Without Proper Motions", *The Astrophysical Journal*, **150**, 57.

Knapp, Wilfried R.A. and Nanson, John, 2017, "A New Concept for Counter-Checking of Assumed CPM Pairs", *JDSO*, **13**, 31-51.

Acknowledgements

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

- Washington Double Star Catalog
- 2MASS All Sky Catalog
- SDSS7/9 Catalog
- SLoPoKES I/II Catalog
- GAIA DR1 Catalog
- Aladin Sky Atlas v9.0
- VizieR
- AstroPlanner v2.2

Appendix - Description of the CPM rating procedure:

- Four rating factors are used: Proper motion vector direction, proper motion vector length, size of position error in relation to proper motion vector length according to Knapp and Nanson 2017 with extension for relation separation to proper motion speed
- Proper motion vector direction ratings: "A" for identical direction within the error range (given by assuming the worst case of the position error pointing in right angle to the PM vector), "B" for similar direction within the double error range, and "C" for outside
- Proper motion vector length ratings: "A" for identical length within the error range (given by assuming the worst case of the position error pointing in the direction of the PM vector), "B" for similar length within the double error range, and C for outside
- Error size ratings: "A" for error size of less than 5% of the proper motion vector length, "B" for less than 10%, and "C" for a larger error size
- Relation separation to proper motion speed: "A" for less than 100 years, "B" for less than 1000 years and "C" for above
- To compensate for excessively large position errors resulting in an "A" rating despite rather high deviations an absolute upper limit is applied regardless of calculated error size:
- Proper motion vector direction: Max. 2.86° difference for an "A" and 5.72° for a "B"
- Proper motion vector length: Max. 5% difference for an "A" and 10% for a "B"
- To compensate for any overly small error "allowance" (result of a combination of very small position error with large PM vector length) the following exceptions are applied:
- If the PM vector direction difference is larger than this calculated "allowed" error but still less than 0.5° then an "A" is given, a "B" is given for larger than 0.5 but less than 1 degree, and a "C" is given if above.
- If the PM vector length difference is larger than this calculated "allowed" error but still less than 0.5% then an "A" is given, a "B" is given for larger than 0.5 but less than 1 percent, and a "C" is given if above.