Double Star Photometry - June 2019

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Abstract: The WDS catalog currently (March 2020) contains about 150,800 objects. About 50,000 of these come with a magnitude for the primary with single digit precision indicating an estimation rather than a precise measurement and over 16,000 objects are listed with magnitudes in the blue or red band (WDS note codes B/K/R/I) and thus in need of a measurement in the V band. After eliminating all objects not suited for resolution with the tools currently available to me (angular separation too small, too faint, too bright), about 26,000 objects remained as targets of interest for this project. The selection criterion for the objects for a specific report is then at a given point of time simply the currently highest given altitude to eliminate atmospheric effects as far as possible – so this is then a more or less random selection out of the mentioned 26,000 objects. This report covers about 70 such objects (including some KPP objects also in need of photometry) with images taken June 2019 with V-filter to allow for visual magnitude measurement by differential photometry. This paper lists also a few WDSS objects as several newly detected likely physical pairs reported in Knapp 2019 were meanwhile included in the WDSS catalog. All objects were additionally checked for potential gravitational relationship using GAIA DR2 data for a Monte Carlo simulation of the spatial distance between the components of a pair and StarHorse median mass values for calculating tidal radii for these components.

1. Introduction

One single image was taken for all selected objects with iTelescope iT24 with V-filter and 20 seconds exposure time and the imaging conditions were overall quite favourable.

The images were plate solved with Astrometrica using the URAT1 catalog with reference stars in the Vmag range of 8.5 to 16.5 giving not only RA/Dec coordinates but also photometry results for all reference stars used including an average Vmag error. The objects were then located in the center of the image and astrometry/photometry was then done by the rather comfortable Astrometrica procedure with point and click at the components delivering RA/Dec coordinates and Vmag measurements based on all reference stars used for plate solving.

2. Results of Image Processing

The measurement results are given in Table 1 with the following structure:

- WDS/WDSS = WDS/WDSS ID
- Disc = WDS discoverer designation (blank for WDSS objects)
- C = Components (AB if blank)
- RA/Dec = Positions for primary and secondary in HH:MM:SS.sss/DD.MM.SS.ss format
- dRA/dDec = Plate solving errors for RA and Dec in arcseconds
- Sep = Calculated separation in arcseconds
- e_Sep = Separation error
- PA = Calculated position angle in degrees
- e_PA = Position angle error
- Mag = Vmags for both components measured by differential photometry
- e_Mag = Magnitude errors
- SNR = Signal to noise ratio for both components
- dVmag = Plate solving error in Vmag
- Date = Julian observation epoch
- Notes = Additional comments listed below Table 1

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WDS/WDSS	Disc	C	RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	Notes
14516+3453	ALI 131		14 51 38.779	34 52 34.39	0.15	0.13	8.74786	0.19849	112.659	1.300	9.817	0.140	100.67	0.14	2019.41891	1)
			14 51 39.435	34 52 31.02							12.156	0.143	36.04			
15157+3642	ALI 601		15 15 43.604	36 41 59.46	0.06	0.09	4.41002	0.10817	292.815	1.405	10.885	0.040	172.57	0.04	2019.41892	1)
			15 15 43.266	36 42 01.17							12.628	0.045	50.56			
15096+2930	BRT 28	A	15 09 23.049	29 31 00.83	0.05	0.06	6.13670	0.07810	209.710	0.729	12.330	0.041	118.32	0.04	2019.41894	1)
		B	15 09 22.816	29 30 55.50							12.270	0.041	117.19			
15096+2930	BRT 28	B	15 09 22.816	29 30 55.50	0.05	0.06	6.37134	0.07810	181.174	0.702	12.270	0.009	117.19	0.04	2019.41894	1)
		C	15 09 22.806	29 30 49.13							12.654	0.041	103.41			
15096+2930	BRT 28	A	15 09 23.049	29 31 00.83	0.05	0.06	12.12235	0.07810	195.169	0.369	12.330	0.041	118.32	0.04	2019.41894	1)
		C	15 09 22.806	29 30 49.13							12.654	0.041	103.41			
15155+3049	BRT 251		15 15 34.100	30 48 20.36	0.08	0.09	5.23061	0.12042	10.072	1.319	12.157	0.041	106.45	0.04	2019.41896	1)
			15 15 34.171	30 48 25.51							13.228	0.043	64.87			
14270+3517	BU 9028	B	14 27 01.968	35 16 27.23	0.09	0.06	13.09059	0.10817	219.713	0.473	11.540	0.041	164.46	0.04	2019.41903	1)
		C	14 27 01.285	35 16 17.16							14.103	0.045	50.11			
15302+4235	BVD 241		15 30 13.174	42 34 23.01	0.07	0.08	18.03097	0.10630	251.068	0.338	15.815	0.045	31.40	0.03	2019.41897	2)
			15 30 11.630	42 34 17.16							15.776	0.047	29.00			
14280+3546	COU1266	A	14 27 58.309	35 47 38.06	0.08	0.10	15.76307	0.12806	274.257	0.465	11.661	0.070	135.98	0.07	2019.41898	1)
		C	14 27 57.017	35 47 39.23							12.776	0.071	90.31			
15080+4355	CVR 778		15 08 02.570	43 54 30.18	0.06	0.07	12.85196	0.09220	316.873	0.411	15.519	0.048	39.46	0.04	2019.41898	1)
			15 08 01.757	43 54 39.56							16.329	0.061	23.30			
15028+3551	DAM 83	B	15 02 42.152	35 51 53.51	0.06	0.06	13.04841	0.08485	284.967	0.373	12.760	0.041	101.00	0.04	2019.41902	1) 5)
		C	15 02 41.115	35 51 56.88							16.253	0.103	10.98			
15028+3551	DAM 83	C	15 02 41.115	35 51 56.88	0.06	0.06	15.23443	0.08485	289.958	0.319	16.253	0.103	10.98	0.04	2019.41902	1) 6)
		D	15 02 39.937	35 52 02.08							16.986	0.138	7.73			
15053+2914	DAM 368		15 05 17.878	29 13 43.76	0.07	0.07	26.43643	0.09899	14.100	0.215	11.025	0.060	185.69	0.06	2019.41899	1)
			15 05 18.370	29 14 09.40							14.284	0.064	48.28			
14557+4355	FYM 235		14 55 44.207	43 55 20.79	0.07	0.08	11.46298	0.10630	351.599	0.531	10.190	0.040	174.80	0.04	2019.41900	1)
			14 55 44.052	43 55 32.13							13.462	0.043	67.31			
14496+4344	FYM 236		14 49 35.986	43 44 21.30	0.10	0.06	17.66585	0.11662	123.772	0.378	11.437	0.041	132.91	0.04	2019.41900	1)
			14 49 37.341	43 44 11.48							12.966	0.042	82.64			
14496+4344	FYM 236	B	14 49 37.341	43 44 11.48	0.10	0.06	30.36377	0.11662	175.496	0.220	12.966	0.042	82.64	0.04	2019.41900	1)
		C	14 49 37.561	43 43 41.21							15.178	0.057	26.02			
14500+4319	FYM 651		14 49 58.785	43 19 06.45	0.06	0.06	8.59804	0.08485	141.727	0.565	13.904	0.035	60.49	0.03	2019.41901	1)
			14 49 59.273	43 18 59.70							14.525	0.039	43.30			
14260+3422	GIC 118		14 25 59.507	34 22 11.96	0.05	0.06	559.73740	0.07810	357.759	0.008	10.243	0.040	220.48	0.04	2019.41901	1)
			14 25 57.739	34 31 31.27							13.540	0.043	65.98			
14554+4354	HDS2106		14 55 25.664	43 54 06.62	0.05	0.04	5.38150	0.06403	39.542	0.682	11.104	0.031	181.96	0.03	2019.41902	1)
			14 55 25.981	43 54 10.77							13.407	0.036	56.02			
15028+3551	HJ 245		15 02 43.374	35 52 01.03	0.06	0.06	16.64948	0.08485	243.149	0.292	12.598	0.041	112.05	0.04	2019.41902	1)
			15 02 42.152	35 51 53.51							12.760	0.041	101.00			

Table 1. Results for measured WDS/WDSS objects

Table 1 continues on the next page.

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WDS/WDSS	Disc	C	RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	Notes
14185+3837	HJ 545		14 18 31.573	38 37 53.39	0.11	0.08	9.15664	0.13601	243.119	0.851	12.737	0.042	89.33	0.04	2019.41903	1)
			14 18 30.876	38 37 49.25							13.238	0.043	75.04			
14270+3517	HJ 550		14 26 59.543	35 16 37.85	0.09	0.06	31.38455	0.10817	109.759	0.197	11.105	0.040	179.84	0.04	2019.41903	1)
			14 27 01.955	35 16 27.24							11.541	0.041	166.44			
14270+3517	BU 9028	B	14 27 01.955	35 16 27.24	0.09	0.06	12.97396	0.10817	219.158	0.478	11.541	0.041	166.44	0.04	2019.41903	1)
		C	14 27 01.286	35 16 17.18							14.104	0.045	51.16			
14453+3649	HJ 557		14 45 18.648	36 48 27.76	0.06	0.05	17.89427	0.07810	48.445	0.250	10.793	0.030	218.33	0.03	2019.41904	1)
			14 45 19.763	36 48 39.63							13.335	0.033	78.78			
15129+3145	HJ 569		15 12 52.948	31 44 11.13	0.07	0.08	13.53711	0.10630	67.731	0.450	13.129	0.052	86.37	0.05	2019.41904	1)
			15 12 53.930	31 44 16.26							14.400	0.020	54.66			
15181+3452	HJ 571		15 18 09.734	34 52 31.83	0.07	0.07	10.07076	0.09899	220.917	0.563	11.535	0.060	159.79	0.06	2019.41905	1)
			15 18 09.198	34 52 24.22							12.351	0.010	112.94			
14454+2911	HJ 2745		14 45 23.167	29 10 53.74	0.08	0.08	12.46251	0.11314	127.694	0.520	9.687	0.050	239.40	0.05	2019.41906	1)
			14 45 23.920	29 10 46.12							12.890	0.051	92.06			
15099+3208	HJ 2769		15 09 58.995	32 09 27.40	0.09	0.11	15.70319	0.14213	22.288	0.519	11.576	0.051	138.05	0.05	2019.41906	1)
			15 09 59.464	32 09 41.93							13.635	0.053	60.08			
14292+4009	KPP 737		14 29 11.217	40 08 58.25	0.06	0.08	6.46079	0.10000	11.984	0.887	11.525	0.008	133.42	0.05	2019.41907	1)
			14 29 11.334	40 09 04.57							12.454	0.051	93.65			
15124+3650	KPP 762		15 12 23.616	36 49 38.62	0.03	0.04	6.62771	0.05000	270.173	0.432	11.226	0.050	194.64	0.05	2019.41623	1)
			15 12 23.064	36 49 38.64							14.334	0.056	42.71			
14512+4518	KPP 865		14 51 14.162	45 17 52.23	0.06	0.06	7.32581	0.08485	218.162	0.664	13.016	0.042	96.40	0.04	2019.42165	1)
			14 51 13.733	45 17 46.47							13.591	0.042	76.61			
15101+4208	KPP1194		15 10 03.732	42 07 29.38	0.05	0.06	9.29519	0.07810	147.737	0.481	12.042	0.060	168.03	0.06	2019.42166	1)
			15 10 04.178	42 07 21.52							12.706	0.061	120.51			
16006-3112	KPP1232		16 00 34.558	-31 12 04.76	0.11	0.11	9.31302	0.15556	200.905	0.957	10.329	0.150	187.41	0.15	2019.42517	3)
			16 00 34.299	-31 12 13.46							16.277	0.157	22.82			
14231+4106	KPP1278		14 23 03.226	41 05 30.19	0.06	0.07	9.69335	0.09220	55.072	0.545	11.379	0.070	210.88	0.07	2019.42167	1)
			14 23 03.929	41 05 35.74							13.409	0.071	83.66			
15170+4109	KPP1471		15 17 00.619	41 09 21.87	0.10	0.09	11.10507	0.13454	145.848	0.694	14.800	0.120	22.68	0.11	2019.41622	1)
			15 17 01.171	41 09 12.68							14.630	0.118	25.31			
16074-3127	KPP2285		16 07 26.366	-31 27 23.41	0.11	0.12	19.28244	0.16279	304.494	0.484	12.146	0.090	146.86	0.09	2019.42518	3)
			16 07 25.124	-31 27 12.49							14.264	0.091	68.11			
15281+4257	KPP2315		15 28 03.340	42 57 04.80	0.06	0.06	19.50863	0.08485	211.295	0.249	13.197	0.051	93.95	0.05	2019.42169	1)
			15 28 02.417	42 56 48.13							13.746	0.052	72.07			
14446+3606	KPP2387		14 44 35.205	36 06 28.54	0.04	0.03	20.58977	0.05000	21.402	0.139	13.378	0.023	98.40	0.02	2019.41624	2)
			14 44 35.825	36 06 47.71							14.339	0.027	61.55			
14523+3344	KPP2427		14 52 17.481	33 44 24.52	0.10	0.12	21.48360	0.15620	282.883	0.417	12.819	0.099	26.00	0.09	2019.41618	1) 7)
			14 52 15.802	33 44 29.31							13.276	0.111	16.43			
14354+3349	KPP3283		14 35 21.861	33 48 56.90	0.07	0.08	11.25538	0.10630	156.992	0.541	10.069	0.060	281.93	0.06	2019.41630	2) 7)
			14 35 22.214	33 48 46.54							16.907	0.116	10.48			

Table 1 (continued). Results for measured WDS/WDSS objects

Table 1 continues on the next page.

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WDS/WDSS	Disc	C	RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	Notes
1434569+323125			14 34 56.935	32 31 25.65	0.08	0.08	16.45251	0.11314	354.619	0.394	11.579	0.050	172.17	0.05	2019.41626	1)
			14 34 56.813	32 31 42.03							15.718	0.067	24.24			
1451558+422143			14 51 55.741	42 21 42.27	0.08	0.12	6.04587	0.14422	103.682	1.367	16.888	0.199	5.14	0.05	2019.41629	2) 8)
			14 51 56.271	42 21 40.84							16.497	0.172	6.11			
1457587+342221			14 57 58.739	34 22 21.01	0.07	0.05	22.49998	0.08602	51.032	0.219	10.834	0.040	214.77	0.04	2019.41624	2)
			14 58 00.152	34 22 35.16							14.717	0.047	43.14			
1459511+321436			14 59 51.165	32 14 34.37	0.15	0.13	31.18997	0.19849	6.962	0.365	13.000	0.113	20.41	0.10	2019.41619	1) 7)
			14 59 51.463	32 15 05.33							13.784	0.138	10.89			
1504122+365201			15 04 12.193	36 52 01.66	0.08	0.08	13.69580	0.11314	31.481	0.473	10.939	0.070	199.01	0.07	2019.41625	2)
			15 04 12.789	36 52 13.34							15.297	0.077	33.21			
1507269+304714			15 07 26.912	30 47 15.03	0.08	0.07	8.80014	0.10630	283.873	0.692	9.738	0.040	251.30	0.04	2019.41625	2)
			15 07 26.249	30 47 17.14							14.908	0.050	36.16			
1517078+334051			15 17 07.747	33 40 52.54	0.09	0.09	9.52596	0.12728	357.973	0.766	10.395	0.050	246.73	0.05	2019.41627	2)
			15 17 07.720	33 41 02.06							15.652	0.066	24.57			
1518536+375547			15 18 53.632	37 55 47.88	0.10	0.09	58.34342	0.13454	346.920	0.132	10.169	0.060	266.56	0.06	2019.41628	1)
			15 18 52.516	37 56 44.71							16.164	0.076	22.70			
1529277+375636			15 29 27.739	37 56 38.52	0.07	0.09	12.04792	0.11402	109.845	0.542	9.403	0.060	315.43	0.06	2019.41628	2) 7)
			15 29 28.697	37 56 34.43							16.246	0.085	17.39			
1530278+364816			15 30 27.653	36 48 17.05	0.08	0.09	32.66008	0.12042	180.126	0.211	7.923	0.061	85.75	0.06	2019.41629	2) 9)
			15 30 27.647	36 47 44.39							15.808	0.079	20.80			
14592+3956	KPP4338	A	14 59 12.370	39 56 15.24	0.07	0.08	6.69689	0.10630	17.697	0.909	15.836	0.065	26.06	0.05	2019.41627	2) 7)
		B	14 59 12.547	39 56 21.62							16.525	0.085	15.22			
14592+3956	KPP4338	A	14 59 12.370	39 56 15.24	0.07	0.08	56.72695	0.10630	309.665	0.107	15.836	0.069	26.06	0.06	2019.41627	2)
		C	14 59 08.573	39 56 51.45							15.955	0.071	24.37			
16029-3210	PRO 128	A	16 02 56.977	-32 09 43.00	0.11	0.12	6.29022	0.16279	130.798	1.482	8.830	0.120	127.48	0.12	2019.41621	3)
		B	16 02 57.352	-32 09 47.11							11.851	0.124	34.18			
16029-3210	KPP4386	A	16 02 56.977	-32 09 43.00	0.11	0.12	44.05602	0.16279	345.801	0.212	8.830	0.120	127.48	0.12	2019.41621	3)
		C	16 02 56.126	-32 09 00.29							15.357	0.123	41.91			
15211+3102	KZA 81		15 21 07.728	31 01 53.07	0.07	0.07	7.99082	0.09899	173.535	0.710	13.605	0.052	75.37	0.05	2019.42170	1) 10)
			15 21 07.798	31 01 45.13							15.297	0.061	31.02			
15216+3059	KZA 83		15 21 37.000	30 59 39.92	0.05	0.06	12.31196	0.07810	43.573	0.363	13.521	0.041	99.09	0.04	2019.42171	4)
			15 21 37.660	30 59 48.84							14.582	0.044	59.20			
15219+3052	KZA 84	A	15 21 59.837	30 52 17.33	0.06	0.08	65.28545	0.10000	354.103	0.088	12.743	0.061	113.02	0.06	2019.42171	1)
		B	15 21 59.316	30 53 22.27							13.215	0.061	87.28			
15219+3052	KZA 84	A	15 21 59.837	30 52 17.33	0.06	0.08	99.12207	0.10000	9.118	0.058	12.743	0.061	113.02	0.06	2019.42171	1)
		C	15 22 01.057	30 53 55.20							13.730	0.062	67.89			
15274+3102	KZA 90		15 27 25.450	31 01 41.16	0.03	0.04	19.88001	0.05000	298.284	0.144	13.924	0.043	63.09	0.04	2019.42172	1)
			15 27 24.088	31 01 50.58							14.745	0.048	40.42			
15309+4145	KZA 92	A	15 30 49.357	41 44 58.54	0.04	0.04	15.17901	0.05657	279.442	0.214	13.725	0.043	71.09	0.04	2019.42172	1)
		B	15 30 48.019	41 45 01.03							14.291	0.045	52.45			
		A	15 30 49.357	41 44 58.54							13.725	0.043	71.09			
		C	15 30 48.295	41 45 21.78							14.576	0.047	42.93			

Table 1 (continued) Results for measured WDS/WDSS objects

Table 1 concludes on the next page.

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WDS/WDSS	Disc	C	RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	Notes
15323+4003	KZA 100	A	15 32 20.616	40 02 51.81	0.04	0.05	19.70541	0.06403	45.833	0.186	12.204	0.051	140.03	0.05	2019.42173	1)
		B	15 32 21.847	40 03 05.54							14.609	0.056	43.85			
15323+4003	TOB 133	A	15 32 20.616	40 02 51.81	0.04	0.05	16.64330	0.06403	287.808	0.220	12.204	0.051	140.03	0.05	2019.42173	1) 7)
		C	15 32 19.236	40 02 56.90							15.878	0.075	18.86			
15340+4110	KZA 101		15 33 57.869	41 09 39.94	0.07	0.07	9.31491	0.09899	205.031	0.609	13.752	0.072	67.73	0.07	2019.42173	1)
			15 33 57.520	41 09 31.50							14.075	0.073	56.78			
14243+3917	LDS 958		14 24 08.626	39 17 27.03	0.08	0.07	11.40932	0.10630	151.430	0.534	11.957	0.060	143.55	0.06	2019.42174	1)
			14 24 09.096	39 17 17.01							12.831	0.061	97.55			
15103+3044	LDS 972		15 10 15.810	30 44 08.56	0.05	0.07	10.85139	0.08602	349.803	0.454	12.283	0.071	117.41	0.07	2019.42174	1)
			15 10 15.661	30 44 19.24							12.745	0.071	97.62			
14415+2957	LDS6298		14 41 27.559	29 57 01.36	0.05	0.07	5.99134	0.08602	102.532	0.823	12.593	0.051	97.21	0.05	2019.42175	1)
			14 41 28.009	29 57 00.06							13.838	0.055	49.49			
14390+3002	MMA 7		14 39 00.419	30 02 03.98	0.06	0.07	17.55449	0.09220	155.946	0.301	11.255	0.050	173.28	0.05	2019.42175	1) 11)
			14 39 00.970	30 01 47.95							14.044	0.055	48.73			
15106+3923	NI 34		15 10 36.373	39 23 14.61	0.06	0.06	7.03732	0.08485	101.891	0.691	13.417	0.082	63.98	0.08	2019.42176	1)
			15 10 36.967	39 23 13.16							14.126	0.083	46.99			
14260+3422	PWS 7	A	14 25 59.500	34 22 11.98	0.08	0.08	26.96191	0.11314	295.412	0.240	10.291	0.070	231.16	0.07	2019.42177	1)
		C	14 25 57.533	34 22 23.55							14.487	0.077	32.44			
14260+3422	PWS 7	A	14 25 59.500	34 22 11.98	0.08	0.08	63.74214	0.11314	215.903	0.102	10.291	0.070	231.16	0.07	2019.42177	1) 12)
		D	14 25 56.481	34 21 20.35							15.936	0.147	7.88			
14260+3422	GIC 118	A	14 25 59.500	34 22 11.98	0.08	0.08	559.70839	0.11314	357.756	0.012	10.291	0.070	231.16	0.07	2019.42177	1) 14)
		B	14 25 57.730	34 31 31.26							13.544	0.072	58.36			
14260+3422	PWS 7	B	14 25 57.730	34 31 31.26	0.08	0.08	88.00245	0.11314	13.588	0.074	13.544	0.072	58.36	0.07	2019.42177	1) 13)
		E	14 25 59.403	34 32 56.80							16.118	0.121	10.46			
14287+3304	TVB 16		14 28 43.437	33 03 53.75	0.04	0.04	49.54408	0.05657	317.178	0.065	10.496	0.040	232.92	0.04	2019.42177	1)
			14 28 40.758	33 04 30.09							11.383	0.041	160.38			
14413+3337	UC 2821		14 41 20.244	33 36 44.92	0.04	0.05	20.14114	0.06403	28.083	0.182	14.804	0.051	34.50	0.04	2019.42178	1) 7)
			14 41 21.003	33 37 02.69							16.383	0.098	11.69			
15129+3430	UC 2960		15 12 56.497	34 30 13.55	0.05	0.05	46.33488	0.07071	268.454	0.087	11.122	0.050	192.92	0.05	2019.42178	1)
			15 12 52.750	34 30 12.30							14.351	0.057	39.14			
15258+3117	UC 3001		15 25 50.284	31 16 48.89	0.06	0.06	5.80962	0.08485	48.231	0.837	13.243	0.072	66.04	0.07	2019.42179	1)
			15 25 50.622	31 16 52.76							13.900	0.074	44.77			
15301+3232	UC 3016		15 30 03.002	32 32 11.89	0.07	0.06	22.63660	0.09220	243.359	0.233	12.032	0.080	129.08	0.08	2019.42179	1)
			15 30 01.402	32 32 01.74							13.887	0.082	53.45			
14488+3232	UR 14		14 48 45.330	32 32 23.36	0.06	0.06	10.73893	0.08485	41.524	0.453	11.755	0.061	139.25	0.06	2019.42180	1)
			14 48 45.893	32 32 31.40							13.465	0.062	62.69			

Table 1 (conclusion) Results for measured WDS/WDSS objects

Notes:

1) iT24 1x20s
2) iT24 1x40s
3) iT32 1x60s
4) iT24 1x30s
5) SNR C <20
6) SNR C <20 and SNR D <10
7) SNR B <20
8) SNR A and B <10
9) Primary saturated and secondary in spike of primary
10) Faint companion close to B
11) SKF1030 BC not resolved
12) SNR D <10
13) SNR E <20
14) GIC 118 listed again due to overlap with PWS 7

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(Continued from page 352)

3. Cross-Match with Gaia DR2

All listed objects were cross-matched with Gaia DR2 to check for potential gravitational relationship by using the DR2 data for a Monte Carlo simulation to determine the spatial distance between the components. Additionally the median StarHorse masses were used to calculate the tidal radii of the components and the minimum period of a potential circular orbit (see Appendix for details). The results are given below in Table 2 with the following structure:

- Object = WDS discoverer designation or WDSS ID
- C = Components (AB if blank)
- pmRA1 = Proper motion primary RA in mas
- pmDE1 = Proper motion primary DE in mas
- pmRA2 = Proper motion secondary RA in mas
- pmDE2 = Proper motion secondary DE in mas
- CPMS = Estimated likelihood for common proper motion
- Plx1 = Parallax primary in mas
- e_Plx1 = Error parallax primary
- Plx2 = Parallax secondary in mas
- e_Plx2 = Error parallax secondary
- Min_D_AU = Minimum spatial distance in AU between components
- LPGR= Likelihood of potential gravitational relationship
- M1_50 = DR2 StarHorse median mass value primary (red type if other source or estimation based for example on luminosity)
- M2_50 = DR2 StarHorse median mass value secondary (red type if other source or estimation based for example on luminosity)
- Min_P_M50= Minimum orbit period with DR2 StarHorse median mass values (blank for LPGR <0.5)
- TR1_AU = Tidal radius primary in AU
- TR2 AU = Tidal radius secondary in AU

Most objects in Table 2 were already cross-matched with Gaia data in other reports, so no 2015.5 values for separation and position angle are given. For the objects with LPGR>50 WDS code "T" is suggested for likely physical by common parallaxes but in most cases the potential orbit period is far too long to detect any changes in separation and position angle by visual observation over a reasonable time frame. For the objects with LPGR <10 WDS code "U" for likely optical is suggested.

4. Objects of Specific Interest

Comments on several of the listed objects:

- GIC 118 (WDS 14260+3422): The components of this pair are listed as high proper motion stars GJ 178-25/26 with very similar proper motion data. Resolved in DR2 with a separation of 559.60962 arcseconds and position angle of 357,754 (per 2015.5, measurement currently not included in the WDS catalog) but with missing parallax and proper motion data for B – so potential gravitational relationship assessment is currently not possible. If the parallax value for B is very similar to A then the likelihood for gravitational relationship is despite the huge angular separation very high
- KPP4338 (WDS 14592+3956): Triple star system with less than 50% likelihood for gravitational relationship despite common proper motion. StarHorse median star masses for the close components A ~0.50 and B ~0.45 added up for assessing gravitational relationship with component C
- BRT 28 (WDS 15096+2930): Most likely optical triple. DR2 parallax for C negative and no StarHorse data available. So no assessment for potential gravitational relationship is possible, but assessment would be optical even with identical parallax values for all components
- COU1266 (WDS 14280+3546): Most likely optical triple. The StarHorse median star masses for the close components A and B of~0.97 /0.84 have been added up for assessing the potential gravitational relationship with component C
- LDS 958 (WDS 14243+3917): Likely physical pair, but the observation history for this object is in relation to the assumed huge minimum orbit period far too short to allow for the calculation of reliable orbital elements
- UC 2960/ KPP4383 (WDS 15129+3430): Most likely physical triple. The StarHorse median star masses for the close components A and C of~0.75 /0.28 have been added up for assessing the potential gravitational relationship with component B. The observation history for this object is in relation to the assumed huge minimum orbit period far too short to allow for the calculation of reliable orbital elements
- PRO 128/ KPP4386 (WDS 16029-3210): Most likely physical triple star system with the StarHorse median star masses for the close components A ~0.95 and B ~0.70 added up for assessing gravitational relationship with component

(Text continues on page 360)

Object	Comp	pmRA1	pmDE1	pmRA2	pmDE2	CPMS	Plx1	e_Plx1	Plx2	e_Plx2	Min_D_AU	LPGR	M1_50	M2_50	P_M50_min	TR1_AU	TR2_AU
ALI 131		-12.278	-7.189	-15.108	-5.618	0	3.5423	0.0253	3.4851	0.0257	2504	8.61	1.57840824	0.92411393	79665	125635	96131
ALI 601		-4.454	15.886	-4.906	15.467	62	2.1753	0.0807	2.2889	0.0225	1985	1.99	1.12201691	0.99257237	61151	105925	99628
BRT 28	AB	-1.506	8.932	-1.470	8.701	39	1.3630	0.0237	1.3143	0.0239	4502	1.57	1.11459005	1.16240954	201323	105574	107815
BRT 251		2.558	11.416	2.461	11.227	78	2.2348	0.0244	2.2012	0.0368	2346	6.51	1.10971236	0.92608744	80065	105343	96233
BU 9028	BC	9.356	-24.879	3.183	-17.712	0	2.8509	0.0259	0.9352	0.0206	128177873	0.00	1.12660313	0.96644312		106142	98308
BVD 241		8.703	-47.694	11.150	-46.377	1	5.2866	0.0272	5.2148	0.0251	3432	7.45	0.54968297	0.54928178	192859	74141	74114
COU1266	AC	-1.607	-25.666	-0.917	-26.292	31	3.6092	0.1246	3.5264	0.0295	4448	7.12	1.8183257	0.89001006	181261	134845	94340
CVR 778		14.595	-46.848	15.558	-47.341	78	6.0677	0.0235	5.8868	0.0420	6420	0.06	0.586797	0.55000627		76603	74162
DAM 83	BC	-14.465	-15.719	-4.085	-2.577	0	2.6981	0.0246	0.0858	0.0518	534446046	0.00	0.93826455	0.88105631		96864	93865
DAM 83	CD	-4.085	-2.577	-4.632	-15.786	0	0.0858	0.0518	0.5546	0.0682	191584944	0.00	0.88105631	0.76419747		93865	87418
DAM 368		28.942	-34.686	1.979	-1.590	0	2.2876	0.0310	0.8864	0.0225	116918269	0.00	1.10054755	0.87599903		104907	93595
FYM 235		-35.794	16.565	14.644	5.285	0	6.0202	0.0251	5.3530	0.0151	3499469	0.00	1.11616802	0.7499485		105649	86600
FYM 236	AB	-1.944	-5.076	1.015	5.126	0	0.7428	0.0248	1.4186	0.0213	96045821	0.00	1.81717348	1.15403044		134803	107426
FYM 236	BC	1.015	5.126	-9.331	-3.288	0	1.4186	0.0213	0.7465	0.0230	93293676	0.00	1.15403044	0.94784707		107426	97357
FYM 651		7.470	-13.471	7.479	-13.348	97	1.4729	0.0164	1.4852	0.0185	5749	5.74	0.97782969	0.87846684	321690	98885	93727
GIC 118		-288.047	-163.587				18.7204	0.0308					0.71640342			84641	
HDS2106		-98.366	21.858	3.288	1.388	0	4.1587	0.0223	1.5667	0.0150	76959053	0.00	1.01935387	0.97562587		100963	98774
HJ 245		-9.574	16.828	-14.465	-15.719	0	2.4935	0.0245	2.6981	0.0246	1755169	0.00	0.9589572	0.93826455		97926	96864
HJ 545		-14.868	-17.906	-14.830	-17.738	97	1.8230	0.0222	1.8373	0.0136	4931	8.74	1.05228388	0.98682624	243827	102581	99339
HJ 550	AB	9.193	-24.855	9.356	-24.879	95	2.8025	0.0282	2.8509	0.0259	11012	8.03	1.12660313	1.25388205	753114	111977	106142
BU 9028	BC	9.356	-24.879	3.183	-17.712	0	2.8509	0.0259	0.9352	0.0206	129561191	0.00	1.29596531	1.07931876		113840	103890
HJ 557		-1.384	4.183	-9.479	-4.904	0	3.2072	0.1139	5.6043	0.4826	2996670	0.00	1.24328959	0.67420071		111503	82110
HJ 569		-12.142	0.367	2.596	-5.647	0	1.1942	0.0216	0.7538	0.0243	62013270	0.00	1.08479381	0.96430647		104153	98199
HJ 571		-20.798	16.964	-20.947	17.017	97	2.1498	0.0266	2.1319	0.0242	4593	9.23	1.21927595	1.04703474	207944	110421	102325
HJ 2745		7.183	-3.464	-36.012	3.049	0	4.1887	0.0672	0.4369	0.0330	297768808	0.00	1.43110442	0.98123032		119629	99057
HJ 2769		-4.754	-0.454	-4.625	5.531	0	0.7510	0.0264	1.1123	0.0164	52023440	0.00	1.09173465	1.0804162		104486	103943
KPP 737		-36.477	5.541	-37.731	5.172	5	4.5887	0.0262	4.6092	0.0246	1402	35.52	0.96836668	0.84652919	39176	98406	92007
KPP 762		13.369	-53.017	13.730	-53.028	97	3.3623	0.0263	3.3942	0.0173	1949	16.17	1.13363004	0.75215507	62995	106472	86727
KPP 865		-46.152	-10.884	-45.252	-8.177	0	3.1314	0.0403	3.2120	0.0139	2297	2.85	0.90190834	0.75055546	86114	94969	86635
KPP1194		27.708	-44.576	27.308	-47.307	4	2.8671	0.0238	2.8540	0.0268	3207	15.99	1.00410509	0.90971845	132008	100205	95379
KPP1232		-27.497	32.446	-24.457	32.394	0	5.9557	0.0531	6.5700	0.0543	1453796	0.00	1.09536171	0.45056438		104660	67124
KPP1278		-6.371	-34.302	-6.214	-34.442	97	1.9368	0.0222	2.1057	0.0146	2713587	0.00	1.31306148	0.92768383		114589	96316
KPP1471		-52.090	22.180	-51.973	22.391	97	2.1987	0.0181	2.1941	0.0178	4950	13.05	0.80948603	0.80622399	275511	89971	89790
KPP2285		-27.085	-19.102	-27.118	-19.089	97	1.9473	0.0466	1.9867	0.0363	9519	4.02	1.14598346	0.86212909	659028	107051	92851
KPP2315		-25.980	38.159	-26.071	38.465	97	2.9276	0.0162	2.9782	0.0156	6594	2.39	0.88597614	0.80264676	414361	94126	89591
KPP2387		-23.856	32.029	-23.833	32.082	97	2.5167	0.0187	2.5578	0.0209	8037	5.68	0.89961785	0.78544545	558098	94848	88625
KPP2427		-38.577	7.476	-38.966	7.394	97	5.3122	0.0276	5.2654	0.0281	3976	24.60	0.79451609	0.78641623	200467	89136	88680
KPP3283		-91.017	122.293	-92.558	123.685	80	12.3304	0.0254	12.2626	0.0418	940	81.11	0.88923627	0.33327028	26218	94299	57730

Table 2: Results for WDS/WDSS objects cross-matched with DR2

Table 2 concludes on the next page.

Object	Comp	pmRA1	pmDE1	pmRA2	pmDE2	CPMS	Plx1	e_Plx1	Plx2	e_Plx2	Min_D_AU	LPGR	M1_50	M2_50	P_M50_min	TR1_AU	TR2_AU
1434569+323125		8.562	7.552	7.406	7.239	1	8.4002	0.0241	8.4402	0.0291	1935	63.28	0.78226888	0.44955844	77089	88446	67049
1451558+422143		-69.815	-61.366	-70.747	-58.148	64	16.3315	0.0514	16.5229	0.0429	389	12.18	0.30112374	0.10000000	12174	54875	31623
1457587+342221		-24.970	-14.738	-24.700	-14.997	97	7.4963	0.0228	7.5481	0.0174	2988	42.54	0.89589983	0.54922241	136648	94652	74110
1459511+321436		-5.434	-74.094	-6.786	-73.893	78	8.9666	0.0286	9.0100	0.0405	3457	65.38	0.70420969	0.67513931	174019	83917	82167
1504122+365201		0.113	11.741	0.937	10.866	0	6.4677	0.0283	6.4616	0.0229	2097	64.35	0.89962214	0.54833275	80253	94848	74049
1507269+304714		-39.641	11.551	-40.531	11.694	39	5.9464	0.0273	5.9782	0.0185	1472	49.21	1.24609315	0.64326817	41313	111629	80204
1517078+334051		-48.264	49.056	-46.581	49.533	62	7.1523	0.0246	7.1204	0.0301	1324	56.67	0.94547701	0.49805927	40332	97236	70573
1518536+375547		-32.561	35.824	-33.170	35.961	76	12.3257	0.0255	12.2505	0.0381	4737	79.13	0.88934904	0.35087180	294342	94305	59234
1529277+375636		-1.059	78.495	-2.194	78.403	97	14.0384	0.0216	14.1258	0.0348	854	92.17	0.91987765	0.30053675	22705	95910	54821
1530278+364816		-70.350	35.696	-68.772	33.882	39	10.1120	0.0245	10.1378	0.0442	3229	89.32	1.36173046	0.44899613	137119	116693	67007
KPP4338	AB	31.380	-100.074	31.318	-100.109	100	7.0719	0.0288	7.0309	0.0341	955	38.07	0.49981353	0.45078489	30443	70697	67141
KPP4338	AC	31.380	-100.074	31.543	-99.432	97	7.0719	0.0288	7.1140	0.0308	7943	46.52	0.95059842	0.50052989	590898	97499	70748
PRO 128	AB	14.986	-8.083	20.564	-10.649	5	17.8766	0.0449	17.9747	0.0599	336	99.30	0.94995517	0.69776762	4820	97466	83532
KPP4386	AC	14.986	-8.083	16.887	-9.911	1	17.8766	0.0449	17.8270	0.0538	2467	99.98	1.64772279	0.40063110	86091	128364	63295
KZA 81		4.130	-5.913	-8.233	-4.594	0	1.1712	0.0158	0.8350	0.0264	39860540	0.00	1.02551091	0.90299577		101268	95026
KZA 83		3.241	-4.234	-3.336	11.967	0	0.8851	0.0152	1.2072	0.0188	41537293	0.00	1.08076024	0.95913965		103960	97936
KZA 84	AB	-33.191	3.311	-3.736	14.395	0	1.1817	0.0220	1.8785	0.0187	49482767	0.00	1.06632674	0.95057410		103263	97497
KZA 84	AC	-33.191	3.311	-30.130	10.845	0	1.1817	0.0220	1.0760	0.0155	96162	0.00	1.06632674	0.87924296		103263	93768
KZA 90		2.617	-31.248	0.004	-5.392	0	1.2724	0.0170	0.5916	0.0217	129670276	0.00	0.9935267	0.94216430		99676	97065
KZA 92	AB	-0.890	-35.792	-25.510	-6.779	0	0.9158	0.0142	0.8092	0.0175	2741666	0.00	0.95292526	0.94978899		97618	97457
KZA 92	AC	-0.890	-35.792	-5.868	8.292	0	0.9158	0.0142	0.7535	0.0187	18170122	0.00	0.95292526	1.01162338		97618	100579
KZA 100	AB	-6.796	-4.484	2.316	-7.776	1	0.4880	0.0196	1.1223	0.0808	143826991	0.00	1.12984598	0.83040154		106294	91126
TOB 133	AC	-6.796	-4.484	-6.430	-3.161	0	0.4880	0.0196	0.4554	0.0319	32976	0.30	1.12984598	0.95606363	4169165	106294	97779
KZA 101		-15.870	-12.682	-14.783	-8.599	0	3.1484	0.0126	2.8285	0.0699	243101	0.00	0.94165927	0.84872156		97039	92126
LDS 958		-61.616	60.642	-62.315	60.997	97	6.6934	0.0249	6.7104	0.0237	1700	69.19	0.84804177	0.79038435	55080	92089	88904
LDS 972		-60.720	65.408	-61.182	65.546	97	3.0781	0.0267	3.0668	0.0273	3486	17.22	0.92553163	0.88164902	153980	96205	93896
LDS6298		-242.333	-74.204	-241.697	-74.255	100	4.7377	0.0338	4.7288	0.0223	1263	35.18	0.79709589	0.69806242	36916	89280	83550
MMA 7	AB	5.859	-2.868	5.994	-3.288	1	3.0388	0.0377	2.8315	0.0408	6021	0.01	1.13633692	0.81318367		106599	90177
NI 34		-136.934	93.448	-129.989	-236.220	0	9.3607	0.0253	8.6784	0.0224	1355839	0.00	0.649854	0.59933537		80614	77417
PWS 7	AC	-288.047	-163.587	5.192	-18.058	0	18.7204	0.0308	1.6057	0.0236	110173773	0.00	0.71640342	0.8455283		84641	91953
PWS 7	AD	-288.047	-163.587	0.611	-0.220	0	18.7204	0.0308	0.3369	0.0466	376535544	0.00	0.71640342	1.06376851		84641	103139
PWS 7	BE			-24.065	-2.463				0.5669	0.1604				0.78494287		0	88597
TVB 16		-4.993	-14.357	-7.605	-17.594	0	0.5360	0.0340	0.8980	0.0337	59056718	0.00	1.13549817	1.1719209		106560	108255
UC 2821		-64.428	13.379	-64.731	13.537	97	2.2771	0.0234	2.2924	0.0461	8671	6.14	0.75319648	0.65033954	685367	86787	80644
UC 2960		-84.807	-25.850	-84.821	-23.985	78	15.5270	0.0240	15.5562	0.0257	2973	100.00	1.035218	0.46499601	133062	101746	68191
UC 3001		-56.999	37.489	-57.245	37.199	100	2.1410	0.0179	2.1131	0.0175	2722	7.14	0.92255819	0.8551262	107100	96050	92473
UC 3016		-60.079	16.365	-60.160	16.706	97	2.8814	0.0492	2.9104	0.0142	7710	10.14	0.96888816	0.7833004	514293	98432	88504
UR 14		-55.782	22.447	-55.141	21.923	78	5.2791	0.0263	5.2218	0.0218	2018	15.90	0.89858049	0.7468487	71083	94793	86420

Table 2 (conclusion). Results for WDS/WDSS objects cross-matched with DR2

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(Continued from page 357)

C. The observation history for this object is in relation to the assumed huge minimum orbit periods far too short to allow for the calculation of reliable orbital elements. Rather different proper motion values might suggest a random encounter

- KPP3283 (WDS 14354+3349): Likely physical pair. The observation history for this object is in relation to the assumed huge minimum orbit period far too short to allow for the calculation of reliable orbital elements.

5. Summary

Many of the measured objects show the expected magnitude difference larger than 0.5 compared with the WDS catalog data especially for the secondary but for many objects the given WDS magnitudes were simply confirmed within the given error range.

12 objects have parallaxes and angular separations allowing for a higher than 50% likelihood for overlapping tidal radii suggesting potential gravitational relationship. If these objects are indeed physical systems then in all cases potential orbits would be in the range of many thousand years, so no human time span is sufficient to sample enough measurements to calculate reliable orbital elements. Additionally all these objects have so far a very "slim" observation history anyway not really suited for the calculation of reliable orbital elements even for much shorter periods. Only 7 of these objects have also proper motion values suggesting common proper motion which might indicate that 5 of these objects are rather random encounters than star systems with gravitational relationship strong enough for an orbit.

29 objects are with a likelihood of 100% opticals and 19 objects have less than 10% likelihood for gravitational relationship. 13 of these objects have DR2 proper motion data suggesting common proper motion – this makes clear once more that common proper motion alone is no good criteria for assessing a double star as likely physical system. Additional 14 objects show less than 50% likelihood for overlapping tidal radii with 11 of these with proper motion data suggesting common proper motion offering room for ambiguity.

6. Acknowledgements:

- The following tools and resources have been used for this research:
- Washington Double Star Catalog
- Gaia DR2 catalog
- DSS2 images
- Aladin Sky Atlas v10.0
- iTelescope
- iT24: 610mm CDK with 3962mm focal length. Resolution 0.625 arcsec/pixel. V-filter. No transformation coefficients available. Located in Auberry, California. Elevation 1405m
- AAVSO VPhot
- Astrometrica v4.10.0.427
- URAT1 catalog
- AstroPlanner v2.2
- MaxIm DL6 v6.08
- Gaia DR2 StarHorse catalog available through the Gaia@AIP services hosted by the Leibniz-Institute for Astrophysics Potsdam using the ADQL query interface at gaia.aip.de

6. References:

F. Anders, A. Khalatyan, et al., 2019, "Photo-astrometric distances, extinctions, and astrophysical parameters for Gaia DR2 stars brighter than G = 18", *Astronomy & Astrophysics,* DOI 10.1051/0004-6361/201935765.

Knapp, Wilfried R. A., 2018, "A New Concept for Counter-Checking of Assumed Binaries", *Journal of Double Star Observations*, **14**, No. 3, 487-491.

Knapp, Wilfried R. A., 2019, "Physical Pairs Found in Gaia DR2", *DSSC27*, pp. 55-72.

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Appendix

Description of the PGR assessment procedure (according to Knapp 2018, extended):

- Gaia DR2 data for RA/Dec and Plx are used for a Monte Carlo simulation assuming a normal distribution for these parameters with the given error range as standard deviation. The distance between the components is calculated from the inverted simulated parallax data and the simulated angular separation using the law of cosine:

$$\sqrt{a^2 - 2ab\cos(\gamma) + b^2}$$

with *a* and *b* = distance vectors for the stars A and B in lightyears calculated as (1000/Plx)*3.261631 and γ = angular separation in degrees calculated as

$$\gamma = \arccos\left[\sin(DE1)\sin(DE2) + \cos(DE1)\cos(DE2)\cos(|RA1 - RA2|)\right]$$

- The tidal radius of the Sun TR($M_\odot$) is considered to correspond with the outer rim of the assumed Oort cloud at a distance of ~100,000 AU as the radius at which the Sun's gravitational force is equivalent to the gravitational force of the stellar neighborhood. For objects with significantly different mass from the Sun this tidal radius TR has to be recalculated for a corresponding gravitational acceleration of 5.87329×10^{-13} m/s^2. Potential gravitational relationship PGR is assumed to be given with overlapping tidal radii of two stellar objects, which does not necessarily mean that an orbit exists but that at least the movement of both stars through space should be noticeable influenced mutually by gravitational forces

- The likelihood for potential gravitational relationship (LPGR) is the percentage of simulation distance results smaller than the sum of the tidal radii TR1+TR2 out of the simulation sample with a size of 120,000 corresponding with the likelihood that the real distance is smaller than TR1+TR2 with an margin of error of 0.37% at 99% confidence

- The minimum, median and maximum distance is the smallest, median and largest result of the simulation sample

- Ignoring the likely effects of eccentricity the smallest/median/largest distance is used as estimation for the value for the semi-major axis of a potential circular orbit. This allows for the calculation of a minimum/median/maximum orbit period assuming zero inclination using either median mass data from StarHorse (Anders et al. 2019) or if not available mass data from other sources (for example estimation from luminosity$^{\wedge(1/4)}$ for assumed masses between 0.43 and 2 Sun masses)