Recovery of Proposed Young Star Binaries in Gaia DR2

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Abstract: A recent paper (Bowler et al. 2019) reports the identification of 221 young star binaries in the solar neighborhood. A common proper motion assessment scheme was used for the purpose to declare a pair as likely binary based on the comparison of multi-epoch images if available. For the remainder of the reported pairs without multi-epoch images available the authors assumed that the vast majority are likely physical binaries due to the low density of comparably bright stars nearby.

This report counterchecks this proposition using GAIA DR2 parallax data allowing to check the likelihood for gravitational relationship by calculating the spatial distance between the components of the proposed binaries. Only 49% of the 221 proposed young star binaries could be successfully cross-matched with GAIA DR2 and only 25% got confirmed as likely binaries but most of these are already known doubles listed in the WDS catalog while the confirmation rate drops dramatically for pairs considered as newly detected. The overall low recovery rate suggests an issue with the GAIA DR2 object coverage in the solar neighborhood.

1. Introduction

Bowler et al. reported in a recent (May 2019) paper the identification of over 200 late-type (≈K7–M5 means late-K and M dwarfs) star binaries in the solar neighborhood selected primarily on the basis of activity indicators from GALEX (Galaxy Evolution Explorer) and ROSAT (All-Sky Survey Bright Source Catalogue). The identification of pairs as "young binaries in the solar neighborhood" is the declared focus of the report and not the detection of new binaries although it is claimed that the vast majority of the reported pairs are new discoveries. This project was started before the release of GAIA DR2 so the meanwhile available parallax values were not used for binary assessment. Instead multi-epoch images were used to test whether components of pairs are likely background stars or physically bound by means of common proper motion. For a good part of the reported pairs no multi-epoch images were available but these were assessed as being physical due to the low density of comparably bright stars nearby. This report checks this proposition using GAIA DR2 parallax data allowing to assess the likelihood for gravitational relationship by calculating the spatial distance between the components.

2. Cross-matching of the Reported Objects with Gaia DR2 and WDS

As the number of objects is reasonable small I decided to follow a simple manual approach with entering the given 2MASS ID into CDS Aladin using DSS or 2MASS images, loading the GAIA DR2 and WDS catalog data for the given view and selecting then the components matching with separation and position angle given by Bowler et al. 2019 in table 4. In some cases with missing proper motion data for one component it was necessary to move the Aladin epoch slider to 2015/16 to identify the correct match.

For the pairs with successful GAIA DR2 matches for both components the data was copied into a spreadsheet calculating epoch 2015.5 separation and position angle, assessing the likelihood for common proper motion in case of existing proper motion values for both components and calculating the spatial distance between the components in case of existing parallax values for both components. To cover the full error range of the given GAIA DR2 values for RA, Dec and Plx a Monte Carlo simulation with a sample size of 120,000

was used to identify significant properties of the resulting distribution of the distance between the components. The smallest possible distance from the simulation was used as most optimistic estimation for the minimum value for the semi-major axis of a potential orbit allowing for the calculation of a smallest possible orbit period assuming zero inclination and in total double Sun mass (approach similar to Farihi et al. 2010). As the likelihood for such a small spatial distance is usually extremely small the same calculation was also done for the median simulation distance to get a more realistic view. Both values should be taken with caution:

- To take the currently measured spatial distance between the components as value for the semi-major axis ignores the influence of eccentricity as it is most likely that the observed separation for high eccentricity pairs is near apastron so the "real" semi-major axis would tend to be somewhat smaller
- The assumed mass of the components as equal to one Sun mass might be considered as very upper limit for the Bowler et al. 2019 objects as these are declared as mostly red dwarfs so an average of 1/3 Sun mass would be more reasonable.

In the few cases with luminosity values available for both components like for example SKF 220 it would have been possible to estimate the mass with the rough relationship $L \sim M^{3.5}$ and with effective temperature values given this estimation might even be enhanced with a stellar class specific luminosity relationship. But the huge spread caused especially by the error range of the DR2 parallax values most likely overcompensates these simplifications anyway.

The results of the matching process including CPM assessment are given in Table 1.

All deltas between the position angle of reported and successfully cross-matched pairs are (with the exception of one case with an exceptionally large GAIA DR2 position error) below 7 degrees and the deltas between the separations of reported and cross-matched pairs are all less than 10%. For about 10% of the successfully cross-matched pairs the visual magnitude of the secondary is more than 1 magnitude fainter than the 15mag threshold declared by the authors.

From 83 pairs reported as likely CPM pairs 43 were successfully cross-matched with GAIA DR2 – the CPM assessment based on GAIA DR2 data confirms common proper motion for only 9 objects. This disappointing result might at least for a part be explained by the high precision of the GAIA DR2 values giving little room for interpretations within the given error range.

The results of the assessment for potential gravitational relationship (PGR) are given in Table 2.

The assessment for potential gravitational relationship is based on the results of a Monte Carlo simulation using the GAIA DR2 values as mean values of normal distributions with the given error ranges as standard deviations (see Appendix for details). In many cases the spread caused by large relative parallax errors is huge and requires even with a sample size of 120,000 repeated simulation runs to cover the full range of possible results.

55 out of 94 objects suitable for potential gravitational relationship (PGR) assessment remained with a likelihood >50% inside the threshold of ~1 parsec distance between the components suggesting these might be likely bound by gravitation with the rest of 40 objects assessed as likely rather optical pairs. This means that 58% of the reported and successfully cross-matched objects are indeed likely binaries with two third of these even with 100% likelihood below the applied threshold of ~1 parsec. On the other side 42% of the reported objects are likely optical pairs with half of these with 100% likelihood outside the threshold meaning zero likelihood for being physical.

From the 102 pairs already known 60 were successfully cross-matched with GAIA DR2 with 51 of them assessed positively for potential gravitational relationship (PGR). From the 119 pairs considered as new discoveries 46 were successfully cross-matched with GAIA DR2 with only 5 of them assessed with a likelihood >50% for PGR plus 9 with a likelihood of at least >10%. This comparison might be a bit unfair as the already known binaries include a few discoveries based on GAIA DR2 data mining – still this result raises questions about the binary attribute of the vast majority of the reported objects considered new discoveries.

3. Discussion of the Results

Out of the 221 listed assumed young binaries 102 are ident with already known double stars (listed in the WDS catalog or already published but per end of April 2019 not yet included in the WDS catalog) and six objects overlap with a component of such double stars. In most such cases a corresponding reference was given by the authors of the report (clearly with exception of the objects not yet listed in the WDS catalog at the time the report was written) but a few matching WDS objects were missed (as for example CRC 74 for J17340562+4447082).

Having begun this study prior to GAIA data releases, the authors approach to selecting targets for follow-up observations has relied only on proper motions and sky positions without the advantage of having parallax-

(Text continues on page 572)

Table 1.

Object	WDS_Disc	Comp?	PA	Sep	PA_DR2	e_PA	Sep_DR2	e_Sep	Vest1	e_Vest1	Vest2	e_Vest2	pmRA1	pmDE1	pmRA2	pmDE2	CPMR	CPMS
J00074264+6022543	JNN 247	SE	94	0.86														
J00133841+5245050	KPP+ 32	BG?	110	3.13	110.425	0.001	3.10005	0.00005	12.34308	0.00173	15.31586	0.02345	61.362	-42.181	59.673	-40.570	ADAA	5
J00160486+2319090	KPP+ 39	SE	94	2.66	96.160	0.003	2.61028	0.00014	14.15838	0.00467	14.57660	0.00354	140.262	-45.645	138.185	-59.868	DCAA	0
J00164045+3000598		SE	174	0.98														
J00165678+2003551		SE	102	1.03														
J00171046+2931520		CPM?	218	1.02														
J00215781+4912379	SKF1600	CPM	303	2.27	300.885	0.003	2.27468	0.00012	12.97999	0.00348	15.53071	0.03149	208.768	-35.025	209.999	-29.251	BAAA	80
J00233468+2014282	SKF2457	SE	136	1.73	139.415	0.004	1.72542	0.00013	11.16978	0.02986	12.01230		65.966	-37.381	56.442	-42.711	DDAA	0
J00285391+5022330	DAE 1	SE	85	0.32														
J00302927+0420204		SE	66	1.70														
J00323480+0729271	MCT 1	CPM	338	0.74														
J00340843+2523498	SKF 220	CPM?	100	1.55	102.342	0.008	1.53405	0.00022	11.83697	0.02166	11.90715	0.05275	82.275	-97.322	86.005	-96.705	BBAA	64
J00414141+4410530	JNN 13	CPM	14	0.51														
J00423409+5439048		BG?	95	3.04														
J00425668+2239350	SKF 229	SE	336	2.96	334.917	0.009	2.91579	0.00048	11.72399	0.00188	14.60123	0.08534	400.509	21.948	400.316	22.505	AAAA	100
J00485822+4435091	MCT 2	CPM	254	1.04	257.168	0.089	1.00149	0.00156	13.09841	0.03122	12.99240		120.296	-130.668	123.185	-135.867	ADAA	5
J00503319+2449009	LDS3203	CPM	324	0.94														
J00530648+4829385		SE	49	1.31	50.425	0.013	1.25273	0.00029	13.05911	0.01850	14.33110		229.279	-143.587	224.346	-152.752	CAAA	20
J01001331+2135328		SE	148	2.63	148.441	0.003	2.62518	0.00014	11.38102	0.00425	12.92170		77.771	12.669	82.105	11.332	BDAA	4
J01001613+1251007		CPM?	359	1.11	358.365	0.656	1.08819	0.01245	11.74022	0.01350	14.13730		47.411	-31.572				
J01034013+4051288	LDS3225BC	SE	97	2.53	97.535	0.003	2.48242	0.00014	13.45846	0.01329	14.51991	0.01196	132.858	-155.877	130.420	-162.474	BBAA	64
J01071194-1935359	BRG 3	SE	166	0.47														
J01093915+2931112		SE	125	0.56														
J01102943-1510071	LDS3239	SE	65	2.38	66.877	0.002	2.32520	0.00008	14.75682	0.00698	14.93911	0.00781	174.194	23.951	173.998	19.823	BAAA	80
J01105436+5822133		SE	81	0.73														
J01112542+1526214	BEU 2	SE	240	0.33														
J03092643+6732425		SE	357	2.78	357.860	0.011	2.57523	0.00049	13.52736	0.00269	18.47240		-67.072	54.409				
J03144720+1127272		BG?	179	0.70														
J03175221+5847431		CPM	67	2.43	68.099	0.005	2.38849	0.00021	11.58474	0.00455	15.44970	0.05884	72.676	-6.710	75.907	-8.481	BDAA	4
J03240643+2347073	WOR 4	CPM	341	2.63	339.848	0.002	2.58773	0.00009	11.02903	0.00495	11.61876	0.12848	215.050	-120.236	200.851	-114.325	ADAA	5
J03323578+2843554	JNN 24	SE	103	0.47														
J03340048+5835551		SE	110	0.81														
J03434696+5725557		SE	241	3.54														
J03520223+2439479	LEI 5	SE	316	0.45														
J04053888+0544408	MCT 3	CPM	253	0.81														
J04074484+0945220		SE	279	0.77														
J04112810+7544231		SE	104	0.27														
J04132663-0139211	MCT 4	SE	175	0.72														
J04134585-0509049	BWL 14AB	SE	104	3.37	107.664	0.004	3.23963	0.00024	14.12417	0.00215	18.67793	0.07951	177.386	-110.102	173.525	-106.544	ACAA	40
J04171645+1213557		CPM?	96	0.73	89.261	0.363	0.74741	0.00474	13.49307	0.01355	13.72010							
J04174337-1754222	KPP+ 618	SE	359	2.78	358.256	0.001	2.69894	0.00006	11.74934	0.00570	15.06992	0.03071	27.773	17.099	32.745	14.472	DDAA	0
J04174431+4103137	NSN 546	CPM?	248	2.46	249.724	0.003	2.43269	0.00013	13.29438	0.00437	15.34765	0.03050	67.514	-209.252	81.592	-215.755	CDAA	1
J04214271-1657543		SE	55	0.41														
J04244805+1552292	HDS 566Aa,Ab	CPM	344	0.31														
J04251456+1858250		SE	140	0.83														
J04282878+1741453	GUE 5	CPM	74	1.72	75.058	0.014	1.65820	0.00042	12.36034	0.01124	13.48420		108.164	-41.789	113.679	-23.714	DAAA	1
J04285080+1617204		CPM?	175	2.00	175.462	0.036	1.93704	0.00123	10.98313	0.00324	14.83000		101.211	-10.376	108.360	-20.265	CDCA	1
J04311384+2053436		SE	217	0.65														
J04325718+7407002	KPP+ 670	SE	323	2.86	321.764	0.001	2.85529	0.00007	12.14488	0.00568	13.76431	0.01605	78.381	-124.919	78.233	-134.382	BDAA	4
J04343992+1512325		SE	175	1.05														
J04350255+0839304		SE	97	0.32														

Table 1 continues on the next page.

Table 1 (continued).

Object	WDS_Disc	Comp?	PA	Sep	PA_DR2	e_PA	Sep_DR2	e_Sep	Vest1	e_Vest1	Vest2	e_Vest2	pmRA1	pmDE1	pmRA2	pmDE2	CPMR	CPMS
J04381255+2813001	BEU 6	CPM	303	1.15	304.513	0.030	1.19322	0.00063	12.76016	0.04621	12.44280		395.646	-92.041	381.115	-83.134	ADAA	5
J04385352+2147549	JNN 262AC	SE	123	1.27	124.772	0.022	1.23643	0.00047	13.65900	0.04553	13.54820		187.715	-213.608	194.097	-208.197	BAAA	80
J04412780+1404340		SE	262	0.26														
J04485498+5527185		SE	262	0.51														
J04492947+4828459	JNN 265	CPM	250	0.63														
J04495635+2341029	KPP3177	CPM?	88	2.51	90.144	0.003	2.38674	0.00013	11.87409	0.01064	12.89471	0.00788	37.179	-170.125	23.076	-161.224	DDAA	0
J05024924+7352143	JNN 30	SE	74	0.34														
J05122408+1824086	KPP+ 798	SE	97	1.50	99.714	0.005	1.45227	0.00012	13.26668	0.05229	12.97760		64.286	-31.912	57.928	-34.583	DDAA	0
J05195513-0723399	JNN 35	SE	286	0.53														
J05252028+6510544	HDS 711	SE	230	1.63	231.210	0.012	1.61282	0.00034	10.68224	0.01391	12.26180		-108.745	19.512	-111.756	17.785	BCAA	32
J05285650+1231539		SE	162	0.23														
J05341064+4732033	KPP+ 890	BG?	14	2.53	14.562	0.002	2.40440	0.00010	12.56094	0.01671	13.78334	0.00949	-58.068	36.848	-47.102	39.608	DDAA	0
J05345873+6521435		SE	276	1.17	275.651	0.009	1.17246	0.00017	11.78648	0.04624	11.69545	0.04376	47.633	-118.803	51.896	-120.795	BCAA	32
J05494518+2513331		CPM?	192	2.79	194.030	0.002	2.74189	0.00009	12.17058	0.02271	14.01094	0.03411	12.678	-47.883	-0.889	1.132	DDAB	0
J05554690+5123592		CPM?	272	1.90	272.123	0.004	1.92394	0.00012	12.80213	0.00432	15.95880		34.305	-105.940	31.057	-103.344	BDAA	4
J06073185+4712266		SE	11	3.45	8.129	0.044	3.54086	0.00271	14.23453	0.00942	18.87619	0.51925	37.768	-188.426				
J06084814+4257182	KPP3189	CPM	354	1.30	352.973	0.006	1.26311	0.00014	13.72664	0.02299	14.12220		39.217	-238.523	45.854	-238.046	BAAA	80
J06101580+2119569		CPM?	51	1.93														
J06133437+4914051		CPM?	25	0.79														
J06462622+0521150		SE	256	4.17	257.300	0.003	4.16881	0.00019	11.35999	0.00187	16.80823	0.08683	59.681	-0.694	1.069	-0.604	DDAB	0
J06584690+2843004		BG	247	1.08														
J07120481+5423473		CPM	336	1.07	333.005	0.032	1.05721	0.00059	13.41331	0.03273	13.50480		12.615	-108.400	13.163	-110.174	ABAA	80
J07140450+5043334	KPP3199	CPM	257	1.91	256.530	0.012	1.90243	0.00039	11.70406	0.00239	14.61420		-130.348	-269.339	-107.017	-282.242	DAAA	1
J07161207+3315154		CPM	52	1.84	53.934	0.015	1.76957	0.00047	11.81721	0.00269	15.82510		-80.561	-182.043				
J07194218+2954390		SE	119	0.48														
J07315773+3613102	BEU 11Aa,Ab	CPM	190	1.55	190.104	0.015	1.55884	0.00041	10.94567	0.01076	12.48550		-249.500	-246.329	-246.029	-248.840	AAAA	100
J07505369+4428181	JNN 59	CPM	142	2.08	142.954	0.004	2.07505	0.00013	12.84270	0.01594	14.18780	0.03117	66.254	-140.517	65.593	-147.670	BDAA	4
J08010582+0334064		SE	351	2.25	350.308	0.016	2.18065	0.00063	13.49355	0.00186	18.83740		-176.781	-124.534	-184.069	-119.057	CBAA	16
J08014318+4959455		CPM	163	1.12	163.805	0.014	1.12045	0.00028	13.16498	0.03700	13.70340		-77.620	-68.602	-69.748	-68.457	CDAA	1
J08083284+5304377		CPM?	139	1.26	140.896	0.013	1.21825	0.00028	13.93016	0.03955	13.91640		-89.351	-91.104	-101.497	-89.248	DDAA	0
J08095207+0301106	KPP+1447	CPM?	34	2.43	34.184	0.001	2.34251	0.00005	12.38162	0.02508	13.14225	0.09762	-15.159	-39.245	-17.262	-39.799	CDAA	1
J08310177+4012115	SKF 207	CPM	119	1.93	121.525	0.002	1.91590	0.00007	14.09077	0.00893	13.52360		-88.340	-124.425	-85.481	-123.378	ABAA	80
J08444213+0044159	KPP+1586	CPM?	116	3.26	117.606	0.001	3.23237	0.00008	10.63284	0.00466	14.46600		-108.177	-9.325	-102.489	-3.659	CDAA	1
J08504234+0751517	VDK 3	CPM	176	1.20	180.641	0.005	1.19683	0.00010	9.47331	0.01099	9.75843	0.04272	-43.414	-26.487	-105.697	14.547	DDAA	0
J08593592+5343505		SE	210	0.37														
J09062111+1659235	SHN 16	SE	280	0.88														
J09132383+6852305		CPM	227	0.60														
J09174473+4612246	JNN 68	SE	348	0.19														
J09192291+6203170		SE	189	0.79														
J09200048+3052397		CPM?	66	0.42														
J09214911+4330284	LAW 17	CPM	126	0.72														
J10024936+4827333		SE	306	0.20														
J10043276+0533412		CPM	324	0.30														
J10143153+0213174		SE	157	0.67														
J10143194+0606409	SKF1633	CPM	268	2.13	268.318	0.003	2.18458	0.00011	13.18608	0.03741	13.48560	0.01599	-143.997	-69.535	-167.415	-73.335	CDAA	1
J10150690+3125110	NSN 601	CPM	305	1.81	306.411	0.005	1.82512	0.00017	14.10586	0.01061	13.57690		-55.054	-213.174	-61.432	-208.138	BBAA	64

Table 1 continues on the next page.

Table 1 (continued).

Object	WDS_Disc	Comp?	PA	Sep	PA_DR2	e_PA	Sep_DR2	e_Sep	Vest1	e_Vest1	Vest2	e_Vest2	pmRA1	pmDE1	pmRA2	pmDE2	CPMR	CPMS
J10452148+3830422	HO 532AC	SE	232	0.68														
J10482887+5852005		BG	307	1.80														
J10571139+0544547	BWL 27	CPM	152	1.01	176.762	4.160	1.01338	0.07371	12.87008	0.01985	13.93890		-59.137	-37.776				
J11030845+1517518		CPM	57	0.39														
J11161238+4942112		CPM?	160	0.79	160.562	0.040	0.81826	0.00057	12.12026	0.01006	13.17520		-74.478	-0.365				
J11432359+2518137		CPM	113	0.48														
J11470543+7001588	NSN 621	SE	138	0.91	138.641	0.032	0.88252	0.00050	13.40660		13.58835	0.01981	-331.166	-50.229	-342.704	-33.527	DCAA	0
J11474897+0459160		CPM	292	1.68	286.480	2.428	1.54102	0.06534	11.60405	0.00185	15.15010		-134.929	-95.433				
J11503435+2903407		N	352	0.51														
J11504306+3312180	SKF 8B	CPM	91	2.58	91.153	0.022	2.78452	0.00107	12.41312	0.00434	15.19782	0.06985	-209.715	5.622	-0.080	-0.070	DDDA	0
J12115308+1249135	CAB 22A	SE	3	1.17	2.529	0.006	1.14504	0.00013	12.84870		12.58870	0.02143	-74.267	-63.983	-71.618	-57.639	BDAA	4
J12121136+4849032	SKF1634	SE	167	2.85	167.997	0.001	2.84340	0.00006	13.06337	0.00168	15.04249	0.01305	197.821	-314.460	207.407	-321.060	ACAA	40
J12161505+5053376		SE	188	1.90														
J12174539+0653230		SE	21	2.63														
J12225061-0404462	BWL 29	SE	29	0.24														
J13020587+1222215	SKF1636	CPM	88	2.93	87.553	0.003	2.88676	0.00017	12.83316	0.00437	15.48353	0.01691	-217.298	-95.688	-223.351	-86.555	CAAA	20
J13034595+2837205		SE	161	1.86	161.608	0.014	1.85107	0.00046	10.99989	0.00665	16.09780		-33.152	20.249	-29.523	18.511	ADAA	5
J13061537+2043444	HU 739	SE	197	1.61	198.896	0.005	1.56411	0.00014	9.93842	0.00960	11.32330		-55.824	94.567	-42.929	60.756	DDAA	0
J13120689+3213179	JNN 90Aa,Ab	SE	315	0.24														
J13151846-0249516	JNN 91	SE	100	0.29														
J13162169+2905548	LDS6276	BG?	72	2.40														
J13252836+3743098	SKF 942	CPM	96	2.91														
J13260267+2735021	KPP+2228	SE	218	1.49	219.364	0.004	1.48482	0.00011	13.27359	0.03232	13.43530		-2.968	73.118	9.228	62.813	DDAA	0
J13282890+0514353		SE	250	0.93														
J13324347+1114521		CPM	86	1.45														
J13324460+1648397	VYS 6	SE	53	2.83	53.732	0.003	2.72252	0.00014	12.05845	0.00742	12.44915	0.01007	287.563	-206.787	288.972	-240.686	DDAA	0
J13373037-1048346		SE	325	0.41														
J13375120+4808174	ES 608	CPM	334	1.63	334.749	0.002	1.63042	0.00006	10.39370	0.02241	11.00138	0.12104	-241.526	-137.716	-201.171	-140.286	DDAA	0
J13420990-1600233	WSI 114	SE	40	0.62														
J13435058+5030053		CPM	50	1.06	51.971	0.024	1.02288	0.00043	13.19386	0.02249	12.94905	0.07285	-80.044	-10.504	-81.724	-12.344	BCBA	30
J13474241+2127374	HDS1939	SE	150	1.33	150.698	0.013	1.30305	0.00030	11.34174	0.01048	12.92500		79.919	-89.265				
J13534589+5210298	JNN 96	SE	349	1.06	350.681	0.062	1.02325	0.00111	13.24525	0.01531	13.36258	0.06253	-2.783	-130.260	12.804	-130.409	DAAA	1
J14040922+2044314	J 1128	CPM	359	0.43														
J14105956+0751398	KPP+2333	BG?	294	1.33	295.272	0.006	1.35850	0.00014	12.91205	0.04364	12.74910		-51.029	9.054	-56.444	-2.113	DDAA	0
J14141700-1521125		CPM?	76	1.61														
J14170294+3142472	DEL 5	SE	175	0.27														
J14170837+5000081		CPM	41	1.70	41.683	0.005	1.61928	0.00013	13.24210	0.01164	14.37890		-105.785	42.292	-104.498	41.268	ABAA	80
J14243178-0257158		SE	217	3.85	218.050	0.008	3.78305	0.00054	12.47388	0.00539	17.39859	0.25293	-66.953	-33.147	-70.224	-29.136	DBAA	1
J14303394+0305440		SE	160	2.69														
J14373999+6745316		BG?	112	0.88														
J14433804-0414354	JNN 100	CPM?	286	1.01	287.548	0.015	1.05390	0.00028	13.05591	0.01528	13.19970		-101.846	-69.609	-112.583	-66.234	DDAA	0
J14445989+5309251		SE	54	0.86	55.116	0.077	0.87004	0.00117	12.49979	0.01561	12.46809	0.01209	-102.145	11.012	-120.064	8.951	BDBA	4
J14514497-0530407		SE	48	0.48														
J15005557+4525343	HDS2118	SE	165	2.03	165.650	0.005	1.99336	0.00017	9.69492	0.00418	11.96700		224.768	328.980	257.599	315.348	DCAA	0
J15072382+4333531		CPM	312	0.55														
J15114542+1014222	DJU 3	SE	250	1.92	251.859	0.003	1.93564	0.00011	12.04352	0.03206	12.69960		-35.994	22.118	-32.144	19.739	ADAA	5
J15123818+4543464	MCT 8	CPM	217	0.54														
J15154371-0725208		SE	193	0.60														
J15233660+3837489		CPM	356	0.62														
J15402840-1841460	HDS2211	SE	37	0.76														
J15422038+5936528		CPM	247	1.58	247.343	0.008	1.60552	0.00023	14.79411	0.00514	17.27130		-88.396	20.796	-88.897	27.136	DCAA	0
J15424184+8005306		CPM?	240	2.08	243.691	0.007	2.02487	0.00024	13.30162	0.02449	13.14740		-45.974	67.326	-50.502	69.394	BDAA	4
J15452354+7514548		SE	143	0.96	142.882	0.080	0.92298	0.00128	13.19253	0.01784	13.57460		-28.939	-63.378	-24.593	-56.745	ADAA	5

Table 1 continues on the next page.

Table 1 (continued).

Object	WDS_Disc	Comp?	PA	Sep	PA_DR2	e_PA	Sep_DR2	e_Sep	Vest1	e_Vest1	Vest2	e_Vest2	pmRA1	pmDE1	pmRA2	pmDE2	CPMR	CPMS
J15521824+3414537	LDS5848	CPM	107	1.80	107.382	0.001	1.83490	0.00003	13.37417	0.02999	13.08840		-78.991	191.130	-65.397	185.422	DDAA	0
J15553178+3512028	MCT 9	CPM	252	1.64	252.711	0.006	1.62802	0.00017	13.73360	0.01083	14.68230		-232.356	155.982	-229.675	137.228	DDAA	0
J15575497+6010263		CPM	297	0.70														
J16015690+1825127		SE	156	1.25	158.400	0.024	1.23786	0.00053	11.99334	0.00728	16.15250		-36.345	-87.737	-28.461	-91.703	DBAA	1
J16043736+7022142		SE	5	0.76														
J16060319+0333215		CPM	305	0.56														
J16102225+4509347		BG?	59	2.43	60.817	0.002	2.31655	0.00009	12.71188	0.01607	15.98012	0.10358	-11.049	29.874	-16.515	33.394	DDAA	0
J16171135+7733477	CAB 23A	SE	263	0.81														
J16250150-1215254		SE	105	0.31														
J16455062+0343014		CPM	188	2.06	189.229	0.004	2.00759	0.00014	12.56191	0.00986	15.53890		-37.665	-105.375	-47.761	-100.607	DAAA	1
J16510995+3555071	JNN 110	CPM	316	1.07														
J16582055+0733079		CPM?	131	0.50														
J17021204+5103284	JNN 112	CPM	62	0.78														
J17035283+3211456	DAE 6	CPM?	150	1.44	150.523	0.031	1.38408	0.00076	12.07902	0.01009	13.08490		192.410	99.967	164.674	68.628	DDAA	0
J17152512+1328342		SE	222	0.74	225.127	0.049	0.74864	0.00065	13.15363	0.00786	13.64950		30.403	23.223	19.042	23.076	DDBA	0
J17183470+3400290	WIS 315	CPM?	83	1.32	85.984	0.010	1.24156	0.00022	13.06807	0.01153	14.58440		-14.624	172.979	-8.602	169.421	BCAA	32
J17340562+4447082	CRC 74	CPM?	145	0.59														
J17380077+3329457	JNN 115	CPM	151	0.97														
J17530062+1655029	CRC 27Aa,Ab	SE	112	0.88														
J17544786+4109310		CPM?	101	0.83														
J18132028+0751536		SE	34	0.98														
J18254891+0409280		SE	181	3.62	181.133	0.002	3.47313	0.00012	12.78057	0.01557	16.96871	0.07448	7.882	-90.950	-0.900	-5.492	DDAA	0
J18320290+2030581	LAW 18	BG?	19	1.38	17.956	0.009	1.38699	0.00022	15.45695	0.02814	16.04609	0.06875	-47.480	-214.651	-51.624	-211.436	BBAA	64
J19011166+2550384		SE	142	1.34	143.151	0.014	1.27627	0.00032	11.77772	0.01344	13.22040		-11.180	36.688	-5.280	45.705	DDAA	0
J19031729+6359341	JOD 16A	SE	64	3.69	65.414	0.014	3.58386	0.00089	10.89090	0.00187	12.42720				78.139	121.301		
J19133270+5644363		SE	167	1.17	167.938	0.015	1.12281	0.00030	13.39159	0.02605	13.73990		-5.845	33.939	9.282	34.584	DDAA	0
J19205158+1903362	SKF1087A	SE	196	0.51														
J19370113+3147214		BG?	303	0.51														
J19433674+3225206	HJ 1433B	SE	73	0.40														
J19471438+6402377		SE	203	0.17														
J19515537+3811071		SE	69	2.32														
J19543755+2013065		SE	113	4.20														
J20013373+2814101	SKF2391	CPM?	119	1.54	121.756	0.003	1.48735	0.00007	13.06801	0.04025	12.78290		114.159	79.540	92.455	76.308	DDAA	0
J20194925+2256367	KPP+3518	SE	357	1.96	355.774	0.004	1.90912	0.00012	12.14114	0.01031	13.15940		83.531	106.694	63.049	122.522	DBAA	1
J20322012+5047455		SE	157	0.82														
J20393474+4822450		CPM?	122	1.86	123.750	0.027	1.83649	0.00088	12.26762	0.01392	13.98130		88.106	48.715	86.638	54.237	DBAA	1
J20395460+0620118		SE	334	2.48														
J20422203+5311332		SE	36	0.29														
J20424915+4122599		CPM	143	0.48														
J20560274-1710538	JAY 2CD	SE	139	2.21	140.368	0.003	2.18199	0.00012	10.74630	0.00964	13.02240		57.311	-62.141	54.711	-64.158	CAAA	20
J21000529+4004136	KUI 103	SE	56	0.89														
J21010182+2615397		SE	99	0.43														
J21143673+1952557		CPM	133	2.86	134.314	0.003	2.86395	0.00014	11.95503	0.00442	15.81566	0.05632	85.763	-48.514	88.104	-47.418	BBAA	64
J21175904+3404301		CPM?	293	1.12	292.678	0.021	1.13822	0.00041	11.76239	0.00963	13.11920		51.540	-23.682	52.424	-13.171	DDAA	0
J21294054+6405399		SE	320	2.44	318.682	0.001	2.51520	0.00005	14.50259	0.01292	15.45302	0.01317	90.903	28.791	-0.211	0.287	DDCA	0
J21322198+2433419	MCT 12	SE	240	1.55	241.192	0.004	1.53164	0.00011	13.11070	0.04726	12.59849	0.04218	229.542	-8.707	211.917	-44.177	DDAA	0
J21363852+3927206	VYS 10	SE	263	1.09														
J21374019+0137137	JNN 291	SE	345	0.42														
J21411161-1011001		SE	14	1.02														
J21501406+0922295		SE	332	1.51	330.699	0.015	1.49319	0.00040	12.70607	0.00575	15.39140		201.509	-295.379	198.080	-299.650	AAAA	100
J21512893-0238147		SE	255	1.43														

Table 1 concludes on the next page.

Table 1 (conclusion).

Object	WDS_Disc	Comp?	PA	Sep	PA_DR2	e_PA	Sep_DR2	e_Sep	Vest1	e_Vest1	Vest2	e_Vest2	pmRA1	pmDE1	pmRA2	pmDE2	CPMR	CPMS
J21521039+0537356	JOD 23AC	SE	16	0.64														
J21543507+5445122	LDS6365	SE	72	3.19	72.737	0.001	3.11957	0.00006	11.80678	0.00122	13.45540	0.00536	171.349	142.350	173.400	140.914	AAAA	100
J21552437+5938371	JNN 292	SE	76	0.36														
J22073842-0650034		SE	287	0.95														
J22300418+4851347	JNN 294	SE	251	2.32	252.470	0.002	2.34027	0.00009	14.08539	0.01318	15.28594	0.01060	-73.658	-61.549	-79.758	-69.964	BDAA	4
J22413501+1849277		SE	264	0.23														
J22413577+2602128		BG?	72	3.70	74.891	0.004	3.61672	0.00026	13.00375	0.00440	18.11566	0.17469	-20.895	59.666	15.993	-6.667	DDAA	0
J22424884+1330532	TDT3670	SE	309	2.24	308.990	0.003	2.26000	0.00013	11.53709	0.07855	11.85263	0.06268	57.145	-34.618	64.156	-34.948	CDAA	1
J22594127+2154070		CPM?	36	2.28	35.238	2.608	2.09310	0.09534	11.00230	0.00443	13.65970		127.972	-59.088				
J23002791-2618431	RST1154	SE	237	2.27	239.293	0.002	2.27603	0.00009	10.51183	0.01100	10.83448	0.02006	116.721	-159.842	99.499	-164.570	DCAA	0
J23024391+7506019	LDS2024	SE	208	3.73	209.050	0.001	3.66919	0.00004	11.51675	0.00190	12.65125	0.00325	285.302	22.953	286.352	17.550	BAAA	80
J23040837+0318214		BG?	300	2.16	300.504	0.006	2.17656	0.00021	11.85066	0.00958	15.74104	0.18944	104.941	-53.343	99.883	-50.932	ADAA	5
J23060295-1556151		SE	25	0.81	24.040	0.250	0.76371	0.00334	13.69815	0.03636	13.70817	0.01572						
J23062378+1236269	HDS3291Aa,Ab	CPM	329	0.46														
J23220944+5756296		SE	312	0.35														
J23450477+1458573	JNN 140AC	CPM?	180	1.15	178.588	0.007	1.15485	0.00015	12.69212	0.02224	12.97740		237.549	-28.932	230.882	-19.235	CDAA	1
J23473777-2316060		SE	64	6.20														
J23574989+3837468	MCT 14	CPM	231	0.47														
J23581366-1724338	DAE 8	SE	176	2.09														
J23590042+2051387	JNN 247	SE	168	0.56														

Content description for table 1:

Object	Given 2MASS ID
WDS_Disc	WDS discoverer code
Comp?	Status of the companion according to Bowler et al. 2019: SE = single epoch without CPM assessment, CPM = common proper motion assumed, BG = background star assumed
PA	Position angle according to Bowler et al. 2019
Sep	Separation according to Bowler et al. 2019
PA_DR2	PA from GAIA DR2 epoch 2015.5 positions (no successful GAIA DR2 cross-match if blank)
e_PA	Error PA from GAIA DR2 positions
Sep_DR2	Separation from GAIA DR2 epoch 2015.5 positions
e_Sep	Error separation from GAIA DR2 positions
Vest1	Estimated primary visual magnitude from GAIA DR2 G/B/R-mags (see Appendix)
e_Vest1	Error estimated primary visual magnitude from GAIA DR2 G/B/R-mags (blank if Vest1 is estimated only from Gmag)
Vest2	Estimated secondary visual magnitude from GAIA DR2 G/B/R-mags (see Appendix)
e_Vest2	Error estimated secondary visual magnitude from GAIA DR2 G/B/R-mags (blank if Vest2 is estimated only from Gmag)
pmRA1	Proper Motion RA primary from GAIA DR2
pmDE1	Proper Motion Dec primary from GAIA DR2
pmRA2	Proper Motion RA secondary from GAIA DR2
pmDE2	Proper Motion Dec secondary from GAIA DR2
CPMR	Common proper motion rating (see Appendix)
CPMS	Common proper motion score (see Appendix)

Table 2

Object	WDS_Disc	Plx1	e_Plx1	Plx2	e_Plx2	Min_AU	Med_AU	Max_AU	L_PGR	P_min_yrs	P_med_yrs	E_Plx1	E_Plx2	Notes
J00074264+6022543	JNN 247													1)
J00133841+5245050	KPP+ 32	18.3065	0.0303	18.4083	0.0573	169	62343	273437	100	1561	11068006	OK	OK	2)
J00160486+2319090	KPP+ 39	26.3998	0.0972	26.5100	0.0669	98	34610	196944	100	694	4578133	OK	OK	2)
J00164045+3000598														1)
J00165678+2003551														1)
J00171046+2931520														1)
J00215781+4912379	SKF1600	33.8287	0.0602	33.7578	0.1084	67	17621	113853	100	391	1663132	OK	OK	
J00233468+2014282	SKF2457	15.8999	0.0623	15.8349	0.0720	109	65437	385143	97	805	11902031	OK	OK	
J00285391+5022330	DAE 1													1)
J00302927+0420204														1)
J00323480+0729271	MCT 1													1)
J00340843+2523498	SKF 220	20.9735	0.1253	19.8590	0.1620	84525	551645	1026250	0	17472783	291321490	!!!	!!!	3)
J00414141+4410530	JNN 13													1)
J00423409+5439048														1)
J00425668+2239350	SKF 229	31.5702	0.1152	31.3449	0.4987	92	78926	550280	91	629	15765638	OK	!!!	
J00485822+4435091	MCT 2	30.3089	0.7965	27.5145	0.9672	62	690487	2299089	6	348	407959081	!!!	!!!	4)
J00503319+2449009	LDS3203													1)
J00530648+4829385		15.3287	0.1077	11.7376	0.2716	2446892	4115022	6173324	0	2721483766	5935287971	!!!	!!!	3)
J01001331+2135328		12.1843	0.1014	11.6418	0.1081	2858	788960	1713703	0	108648	498271751	!!!	!!!	3)
J01001613+1251007		10.6210	0.0468									OK		5)
J01034013+4051288	LDS3225BC	32.4949	0.0604	32.7415	0.1185	76	47831	175975	100	474	7437950	OK	OK	6)
J01071194-1935359	BRG 3													1)
J01093915+2931112														1)
J01102943-1510071	LDS3239	22.9845	0.0523	23.0986	0.0532	101	44459	164156	100	718	6665367	OK	OK	
J01105436+5822133														1)
J01112542+1526214	BEU 2													1)
J03092643+6732425		19.7872	0.2785									!!!		5)
J03144720+1127272														1)
J03175221+5847431		9.9720	0.0343	10.6111	0.1936	535	1245118	2640573	0	8804	987869369	OK	!!!	3)
J03240643+2347073	WOR 4	48.2954	0.0494	48.0921	0.0617	54	18061	49565	100	280	1725883	OK	OK	
J03323578+2843554	JNN 24													1)
J03340048+5835551														1)
J03434696+5725557														1)
J03520223+2439479	LEI 5													1)
J04053888+0544408	MCT 3													1)
J04074484+0945220														1)
J04112810+7544231														1)
J04132663-0139211	MCT 4													1)
J04134585-0509049	BWL 14AB	33.7578	0.2165	33.8695	0.2002	95	38402	242591	100	656	5350739	!!!	!!!	
J04171645+1213557														5)
J04174337-1754222	KPP+ 618	13.6412	0.0362	13.7054	0.0550	197	74940	402994	96	1966	14586509	OK	OK	2)
J04174431+4103137	NSN 546	32.7314	0.0710	33.0888	0.1122	74	67943	193920	100	455	12592280	OK	OK	7)
J04214271-1657543														1)
J04244805+1552292	HDS 566Aa,Ab													1)
J04251456+1858250														1)
J04282878+1741453	GUE 5	21.3301	0.2602	21.8172	0.2314	78	215932	872147	46	486	71344388	!!!	!!!	4)
J04285080+1617204		18.3652	1.1446	20.8078	0.1219	94	1323069	5863977	3	644	1082074296	!!!	!!!	4)
J04311384+2053436														1)

Table 1 continues on the next page.

Table 2 (continued)

Object	WDS_Disc	Plx1	e_Plx1	Plx2	e_Plx2	Min_AU	Med_AU	Max_AU	L_PGR	P_min_yrs	P_med_yrs	E_Plx1	E_Plx2	Notes
J04325718+7407002	KPP+ 670	29.5407	0.0443	29.3179	0.0521	105	53047	127573	100	762	8687185	OK	OK	2)
J04343992+1512325														1)
J04350255+0839304														1)
J04381255+2813001	BEU 6	73.4184	0.4604	75.4857	0.1877	74	76968	158900	100	450	15182693	!!!	OK	
J04385352+2147549	JNN 262AC	24.3883	0.3885	21.8398	0.1331	313289	986382	1585797	0	124681541	696548754	!!!	!!!	3)
J04412780+1404340														1)
J04485498+5527185														1)
J04492947+4828459	JNN 265													1)
J04495635+2341029	KPP3177	24.3598	0.0934	24.5521	0.0547	97	66316	240951	100	683	12142547	OK	OK	7)
J05024924+7352143	JNN 30													1)
J05122408+1824086	KPP+ 798	18.8345	0.0675	18.6814	0.0709	77	89671	344895	97	481	19092487	OK	OK	2)
J05195513-0723399	JNN 35													1)
J05252028+6510544	HDS 711	26.2810	0.0279	26.1718	0.2407	61	54160	346216	99	342	8961904	OK	!!!	8)
J05285650+1231539														1)
J05341064+4732033	KPP+ 890	30.0792	0.0452	30.0718	0.0734	80	13251	90974	100	507	1084588	OK	OK	2)
J05345873+6521435		19.1742	0.0778	18.6521	0.1506	67	300679	765420	16	387	117230084	OK	!!!	4)
J05494518+2513331		9.6659	0.0582	0.3813	0.0388	348770390	519360136	9915350665	0	4631193312157	8415625819857	!!!	!!!	3)
J05554690+5123592		16.4271	0.0376	16.6977	0.1025	117	203417	543597	48	902	65232661	OK	!!!	4)
J06073185+4712266		35.3362	0.1100									OK		5)
J06084814+4257182	KPP3189	20.9978	0.0628	21.2296	0.0905	61	107255	320011	97	338	24975360	OK	OK	7)
J06101580+2119569														9)
J06133437+4914051														1)
J06462622+0521150		23.3429	0.0511	0.4962	0.2039	145183880	406451077	3031630001370	0	1243830200713	5826341244245	OK	!!!	3)
J06584690+2843004														1)
J07120481+5423473		13.0040	0.6431	17.1461	0.0889	996853	3833859	8479756	0	707669312	5337498203	!!!	!!!	3)
J07140450+5043334	KPP3199	35.1701	0.0344	34.7427	0.0887	1203	72103	151373	100	29673	13766140	OK	OK	7)
J07161207+3315154		34.9370	0.0675									OK		5)
J07194218+2954390														1)
J07315773+3613102	BEU 11Aa,Ab	83.3360	0.0462	81.8459	0.3420	2196	44973	90882	100	73193	6781168	OK	OK	
J07505369+4428181	JNN 59	20.0063	0.0357	20.4367	0.1246	372	216984	523161	40	5110	71866462	OK	!!!	4)
J08010582+0334064		21.2928	0.0466	21.7093	0.8196	102	282223	1726098	37	733	106603718	OK	!!!	4)
J08014318+4959455		17.6589	0.2652	16.0828	0.0970	270096	1145034	1945519	0	99807159	871186648	!!!	!!!	3)
J08083284+5304377		28.5698	0.2544	29.7167	0.1340	875	278666	594533	14	18403	104594508	!!!	OK	4)
J08095207+0301106	KPP+1447	10.2325	0.0356	10.2347	0.0379	228	69291	422970	95	2445	12968700	OK	OK	2)
J08310177+4012115	SKF 207	29.6987	0.0626	29.6311	0.0487	65	17472	88671	100	369	1642093	OK	OK	
J08444213+0044159	KPP+1586	15.3762	0.0381	15.2787	0.0557	210	86081	351416	97	2164	17957328	OK	OK	2)
J08504234+0751517	VDK 3	56.1890	0.0685	56.1155	0.0647	21	5513	31314	100	70	291055	OK	OK	
J08593592+5343505														1)
J09062111+1659235	SHN 16													1)
J09132383+6852305														1)
J09174473+4612246	JNN 68													1)
J09192291+6203170														1)
J09200048+3052397														1)
J09214911+4330284	LAW 17													1)
J10024936+4827333														1)
J10043276+0533412														1)
J10143153+0213174														1)

Table 1 continues on the next page.

Table 2 (continued)

Object	WDS_Disc	Plx1	e_Plx1	Plx2	e_Plx2	Min_AU	Med_AU	Max_AU	L_PGR	P_min_yrs	P_med_yrs	E_Plx1	E_Plx2	Notes
J10143194+0606409	SKF1633	30.9057	0.0563	31.0992	0.0674	70	41617	122568	100	420	6036540	OK	OK	
J10150690+3125110	NSN 601	29.7933	0.0726	30.0216	0.0811	61	52786	162713	100	340	8623184	OK	OK	7)
J10452148+3830422	HO 532AC													1)
J10482887+5852005														1)
J10571139+0544547	BWL 27	9.5289	0.4461									!!!		5) 19)
J11030845+1517518														1)
J11161238+4942112		12.6285	0.3654									!!!		5)
J11432359+2518137														1)
J11470543+7001588	NSN 621	32.8054	0.0755	32.5949	0.3916	27	59457	373792	98	99	10308348	OK	!!!	7)
J11474897+0459160		26.2972	0.0538									OK		5)
J11503435+2903407														1)
J11504306+3312180	SKF 8B	20.4047	0.8202	0.6751	0.2849	98557089	294655431	5856173227290	0	695689265992	3596293896331	!!!	!!!	3) 10)
J12115308+1249135	CAB 22A	16.1273	0.0976	16.3878	0.0793	70	203539	615083	49	420	65291328	!!!	OK	11)
J12121136+4849032	SKF1634	37.6051	0.0343	37.8615	0.0631	79	37157	86433	100	502	5092606	OK	OK	
J12161505+5053376														1)
J12174539+0653230														1)
J12225061-0404462	BWL 29													1)
J13020587+1222215	SKF1636	33.0956	0.0782	33.1929	0.1318	87	23540	145681	100	576	2568014	OK	OK	
J13034595+2837205		4.6654	0.0363	3.8962	0.3847	560	8737383	46547389	1	9412	18363505711	!!!	!!!	4)
J13061537+2043444	HU 739	50.9035	0.0435	50.7329	0.1295	31	13814	64447	100	121	1154391	OK	OK	
J13120689+3213179	JNN 90Aa,Ab													1)
J13151846-0249516	JNN 91													1)
J13162169+2905548	LDS6276													1)
J13252836+3743098	SKF 942													1)
J13260267+2735021	KPP+2228	22.1232	0.0786	21.9462	0.0550	67	75412	271785	100	394	14724711	OK	OK	2)
J13282890+0514353														1)
J13324347+1114521														1)
J13324460+1648397	VYS 6	60.3012	0.1130	60.3748	0.0826	45	6097	38043	100	215	338511	OK	OK	
J13373037-1048346														1)
J13375120+4808174	ES 608	47.1938	0.0302	47.2225	0.0321	35	3376	21507	100	144	139451	OK	OK	
J13420990-1600233	WSI 114													1)
J13435058+5030053		16.0118	0.3808	15.7766	0.0914	65	257859	1486520	40	371	93101552	!!!	!!!	4)
J13474241+2127374	HDS1939	33.4010	0.0404									OK		5)
J13534589+5210298	JNN 96	17.8099	0.8939	21.6613	0.3092	182	2060734	5221024	0	1740	2103374154	!!!	!!!	3)
J14040922+2044314	J 1128													1)
J14105956+0751398	KPP+2333	29.1804	0.0915	29.3457	0.0975	47	40588	179774	100	226	5814127	OK	OK	2)
J14141700-1521125														1)
J14170294+3142472	DEL 5													1)
J14170837+5000081		15.5384	0.0864	15.5979	0.0810	103	77289	474693	92	748	15277839	!!!	!!!	12)
J14243178-0257158		7.6029	0.2839	7.2458	0.4900	506	1715399	12350461	6	8093	1597463951	!!!	!!!	4)
J14303394+0305440														1)
J14373999+6745316														1)
J14433804-0414354	JNN 100	19.3726	0.1992	19.4511	0.1454	54	95840	631739	84	279	21096175	!!!	!!!	
J14445989+5309251		16.9706	0.6239	17.9050	0.6905	50	670954	3441820	15	250	390771056	!!!	!!!	4)
J14514497-0530407														1)

Table 1 continues on the next page.

Table 2 (continued)

Object	WDS_Disc	Plx1	e_Plx1	Plx2	e_Plx2	Min_AU	Med_AU	Max_AU	L_PGR	P_min_yrs	P_med_yrs	E_Plx1	E_Plx2	Notes
J15005557+4525343	HDS2118	85.3753	0.0367	85.3829	0.1132	23	2290	14586	100	80	77919	OK	OK	
J15072382+4333531														1)
J15114542+1014222	DJU 3	9.1826	0.0468	9.0769	0.0768	211	266424	1297435	37	2172	97778624	!!!	!!!	4)
J15123818+4543464	MCT 8													1)
J15154371-0725208														1)
J15233660+3837489														1)
J15402840-1841460	HDS2211													1)
J15422038+5936528		22.4619	0.0334	22.6702	0.1522	71	85077	358678	97	428	17644305	OK	!!!	12)
J15424184+8005306		13.0841	0.0187	12.1865	0.1797	139611	1161541	2271036	0	37090500	890092433	OK	!!!	3)
J15452354+7514548		20.2010	0.9409	16.7651	0.0512	1111	2092139	4078920	0	26345	2151638606	!!!	OK	3)
J15521824+3414537	LDS5848	21.9104	0.0203	21.9590	0.0209	84	20792	76498	100	544	2131745	OK	OK	
J15553178+3512028	MCT 9	35.9423	0.0441	36.1520	0.1320	45	33265	131265	100	217	4313848	OK	OK	
J15575497+6010263														1)
J16015690+1825127		15.3177	0.0505	13.3188	0.4637	18132	2020175	4683308	0	1736010	2041582089	OK	!!!	3)
J16043736+7022142														1)
J16060319+0333215														1)
J16102225+4509347		9.9047	0.0470	9.7932	0.0591	234	237509	1044972	41	2547	82300688	OK	!!!	4)
J16171135+7733477	CAB 23A													1) 13)
J16250150-1215254														1)
J16455062+0343014		22.2755	0.0409	21.9823	0.1205	90	123484	351915	92	611	30853193	OK	!!!	12)
J16510995+3555071	JNN 110													1)
J16582055+0733079														1)
J17021204+5103284	JNN 112													1)
J17035283+3211456	DAE 6	52.2800	0.3416	53.3747	0.4858	27	80764	255757	100	97	16319545	!!!	!!!	
J17152512+1328342		18.5272	0.4927	16.3825	0.2464	17950	1457330	2886724	0	1709923	1250893444	!!!	!!!	3)
J17183470+3400290	WIS 315	19.7804	0.0265	19.6978	0.1337	63	58059	357043	98	354	9946861	OK	!!!	14)
J17340562+4447082	CRC 74													1)
J17380077+3329457	JNN 115													1)
J17530062+1655029	CRC 27Aa,Ab													1)
J17544786+4109310														1)
J18132028+0751536														1)
J18254891+0409280		18.1840	0.0347	0.3628	0.0861	27293344 4	5580748 00	39234638 6786	0	3206037758758	9373938885129	OK	!!!	3)
J18320290+2030581	LAW 18	32.0541	0.1700	31.9576	0.0978	43	30262	201200	100	203	3743158	!!!	OK	
J19011166+2550384		20.4640	0.0578	19.5055	0.1992	38322	495372	1011607	0	5334033	247902225	OK	!!!	3)
J19031729+6359341	JOD 16A			27.4538	0.0345								OK	5) 15)
J19133270+5644363		14.4455	0.1406	14.6150	0.1026	77	175241	886055	56	479	52159783	!!!	!!!	
J19205158+1903362	SKF1087A													1) 16)
J19370113+3147214														1)
J19433674+3225206	HJ 1433B													1) 17)
J19471438+6402377														1)
J19515537+3811071														1)
J19543755+2013065														1)
J20013373+2814101	SKF2391	29.5022	0.0502	29.5712	0.0587	50	17733	94174	100	253	1678990	OK	OK	

Table 1 concludes on the next page.

Table 2 (conclusion)

Object	WDS_Disc	Plx1	e_Plx1	Plx2	e_Plx2	Min_AU	Med_AU	Max_AU	L_PGR	P_min_yrs	P_med_yrs	E_Plx1	E_Plx2	Notes
J20194925+2256367	KPP+3518	34.0809	0.0740	33.9938	0.1082	56	19324	122134	100	296	1910017	OK	OK	2)
J20322012+5047455														1)
J20393474+4822450		13.0459	0.0332	13.2609	0.6222	141	538028	3852648	20	1194	280601968	OK	!!!	
J20395460+0620118														1)
J20422203+5311332														1)
J20424915+4122599														1)
J20560274-1710538	JAY 2CD	21.7720	0.0984	21.6204	0.0727	101	67370	299198	99	720	12433237	OK	OK	
J21000529+4004136	KUI 103													1)
J21010182+2615397														1)
J21143673+1952557		8.1923	0.0637	9.2534	0.1238	1310331	2887922	4323547	0	1066485987	3489487103	!!!	!!!	3)
J21175904+3404301		23.0003	0.0652	24.1211	0.3098	198	416851	909331	3	1982	191361854	OK	!!!	4)
J21294054+6405399		22.8137	0.0340	0.4941	0.0290	327783306	408436139	549910321	0	4219526769692	5869076135284	OK	!!!	3)
J21322198+2433419	MCT 12	48.6656	0.0810	48.8403	0.0854	31	15170	58902	100	125	1328449	OK	OK	
J21363852+3927206	VYS 10													1)
J21374019+0137137	JNN 291													1)
J21411161-1011001														1)
J21501406+0922295		22.5412	0.0579	23.1404	0.4096	67	237187	843316	41	386	82133336	OK	!!!	4)
J21512893-0238147														
J21521039+0537356	JOD 23AC													1)
J21543507+5445122	LDS6365	14.0358	0.0312	14.0882	0.0352	221	56260	283763	100	2342	9488251	OK	OK	
J21552437+5938371	JNN 292													1)
J22073842-0650034														1)
J22300418+4851347	JNN 294	30.0624	0.0610	29.9626	0.0539	78	23253	112849	100	488	2521128	OK	OK	
J22413501+1849277														1)
J22413577+2602128		33.1194	0.0583	0.9876	0.2431	96399380	202618569	129259840008	0	672968688509	2050701104180	OK	!!!	3)
J22424884+1330532	TDT3670	14.4733	0.0691	14.7603	0.0835	155	277748	758948	23	1375	104078289	OK	!!!	4)
J22594127+2154070		26.3047	0.0514									OK		5)
J23002791-2618431	RST1154	31.3880	0.0485	31.4730	0.0610	72	18265	93683	100	438	1755190	OK	OK	
J23024391+7506019	LDS2024	18.8105	0.0255	18.8792	0.0199	195	39848	124652	100	1933	5655759	OK	OK	
J23040837+0318214		11.6425	0.0457	11.7279	0.1530	187	187872	1094142	53	1814	57899801	OK	!!!	
J23060295-1556151														5)
J23062378+1236269	HDS3291Aa,Ab													1)
J23220944+5756296														1)
J23450477+1458573	JNN 140AC	13.9298	0.1457	14.2437	0.0650	83	325509	1099342	22	541	132046667	!!!	OK	4)
J23473777-2316060														1) 18)
J23574989+3837468	MCT 14													1)
J23581366-1724338	DAE 8													1)
J23590042+2051387	JNN 247													1)

Recovery of Proposed Young Star Binaries in Gaia DR2

Content description for table 2:

- Object Given 2MASS ID
- WDS_Disc WDS discoverer code
- Plx1 Parallax primary from GAIA DR2
- e_Plx1 Error parallax primary from GAIA DR2
- Plx2 Parallax secondary from GAIA DR2
- e_Plx2 Error parallax secondary from GAIA DR2
- Min_AU Minimum distance between components in AU (see Appendix)
- Med_AU Median distance in AU (see Appendix)
- Max_AU Maximum distance in AU (see Appendix)
- L_PGR Likelihood for distance < 200,000 AU
- P_min_yrs Minimum orbit period in years (see Appendix)
- P_med_yrs Medium orbit period in years (see Appendix)
- E_Plx1 Relation e_Plx/Plx for primary ("OK" for <0.5%, else "!!!")
- E_Plx2 Relation e_Plx/Plx for secondary ("OK" for <0.5%, else "!!!")
- Notes Notes (see below)

Notes:

1. Not resolved in DR2
2. Reported in Knapp 2019, Physical Pairs found in GAIA DR2, DSSC27, Pages 55-72
3. Most likely optical
4. Likelihood optical >50%
5. Resolved in DR2 w/o Plx
6. Wrong 2MASS ID, should be J01034013+4051288. Given ID is for LDS3225A. Physical triple
7. Reported in Knapp and Nanson 2019, A Catalog of High Proper Motion Stars in the Northern Sky (HPMSNS Catalog), JDSO Vol. 15 No. 1, Pages 42-58
8. B double itself?
9. Resolved in DR2 but with Sep and PA too different to be considered a valid match
10. Overlap with SKF 8B
11. Overlap with CAB 22A
12. Plx error too large to be included in 2)
13. Overlap with CAB 23A
14. Overlap with WIS 315A
15. Overlap with JOD 16A
16. Overlap with SKF1087A
17. Overlap with HJ 1433B
18. Might be bogus – no object for the secondary to locate at the given position. May be typo for separation with 6.2 instead of 1.2”. Object for secondary given here but without data for CPM and PGR assessment

Recovery of Proposed Young Star Binaries in Gaia DR2

(Continued from page 560)

es. This seems to have worked reasonable well as with a few exceptions all matched objects are according to the GAIA DR2 parallaxes clearly within the declared search radius of 100 parsecs – only 10% of the objects with GAIA DR2 parallax data available are listed with parallax values <10 and only 6 of the assumed companions are obviously background stars with parallax values <1. The assessment of the identified pairs for being physicals was done on base of assumed common proper motion based on tests using multi-epoch images – as common proper motion is not a sufficient criterion for such an assessment (Knapp 2019) this has the unavoidable consequence of declaring pairs as likely physical while the components are due to the given spatial distance clearly without any reasonable likelihood for gravitational relationship. As comparison of multi-epoch images was only available for a part of the reported pairs the authors assumed that the vast majority of the single epoch objects are expected to be physical binaries based on the low number density of comparably bright stars nearby – this might be a case of motivated perception rather than a serious assessment.

Out of the 221 listed assumed young binaries 106 could be successfully matched with GAIA DR2 objects with 94 of them with proper motion and parallax data available for common proper motion and potential gravitational relationship (PGR) assessment.

In total 115 reported objects could not be matched with corresponding GAIA DR2 objects giving a meagre overall recovery rate of 49% compared with for example the 99% for SKF objects (Knapp 2019).

But 24 objects are listed with a separation <0.4 arcseconds below the resolution limit of GAIA DR2 (Arenou et al. 2018) and 73 with a separation <1 arcsecond which means in a range known for a bad GAIA DR2 resolution performance – yet in this case this performance is especially bad: Only 7 out of 73 objects with a separation <1 arcsecond are resolved.

24 out of 123 objects listed with a separation >1" remain also without resolution in GAIA DR2 – this gives a recovery rate of ~80% for such objects. This result is in comparison with other known double stars of similar separation rather modest yet does not allow for a prematurely conclusion that some of the proposed binaries might be bogus – the provided image material looks despite some gaps (for example images for J19543755+2013065 and J20194925+2256367 are missing) and some mislabeling (for example J22413577+2602128 instead of J22413501+1849277 or J01001613+1251007 instead of J01034013+4051288) very convincing.

4. Summary

Only 49% of the 221 proposed young star binaries could be successfully cross-matched with GAIA DR2 and only 42.5% with proper motion and parallax data available for both components. 25% are confirmed as likely binaries but most of these are already known doubles listed in the WDS catalog while this confirmation rate drops dramatically for pairs reported as newly detected.

The overall low recovery rate indicates either an issue with the data of the reported young binaries or an issue with GAIA DR2 data quality - the known weakness of GAIA DR2 with very high proper motion objects in the solar neighborhood (Knapp and Nanson 2019) suggests the latter. This conclusion is supported by several cases of GAIA DR2 cross-match mishits with obviously existing objects in PanSTARRS1 images in the given positions.

5. Acknowledgements

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

- Washington Double Star Catalog
- GAIA DR2 catalog
- DSS, 2MASS and Pan-STARRS (PS1) images
- Aladin Sky Atlas

References:

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Recovery of Proposed Young Star Binaries in Gaia DR2

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Appendix

Description of the CPM rating procedure (according Knapp and Nanson 2017 and Knapp 2018):

- Four rating factors are used: Proper motion vector direction, proper motion vector length, size of position error in relation to proper motion vector length and relation separation to proper motion speed
- Proper motion vector direction ratings: "A" for within the error range of identical direction, "B" for similar direction within the double error range, "C" for direction within the triple error range and "D" for outside
- Proper motion vector length ratings: "A" for identical length within the error range, "B" for similar length within the double error range, "C" for length within the triple error range and "D" for outside
- Error size ratings: "A" for error size of less than 5% of the proper motion vector length, "B" for less than 10%, "C" for less than 15% and "D" for a larger error size
- Relation separation to proper motion speed: "A" for less than 100 years, "B" for less than 1000 years, "C" or less than 10000 years and "D" for above

To compensate for the extremely small proper motion GAIA DR2 errors resulting in a worse than "A" rating despite only very small deviations an absolute lower limit is applied regardless of calculated error size:

- Proper motion vector direction: Max. 1° difference for an "A"
- Proper motion vector length: Max. 1% difference for an "A"

The letter based scoring is then transformed into an estimated probability and a verbal assessment for being CPM.

Description of the PGR assessment procedure (according to Knapp 2019):

- 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

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

cosine 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

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

- The potential gravitational relationship score (PGRS) is the percentage of simulation results <200,000 AU (~1 parsec) out of the simulation sample with a size of 120,000 corresponding with the likelihood that the real distance is smaller than 200,000 AU
- The smallest, median and largest distance is the smallest, median and largest result of the simulation sample
- The smallest/median/largest distance is also used as estimation for the minimum value for the semi-major axis of a potential orbit allowing for the calculation of a smallest/median/largest possible orbit period assuming zero inclination and in total double Sun mass.

Estimation of visual magnitudes (according Knapp and Nanson 2018):

The estimation of the visual magnitudes is based on GAIA DR2 G/B/R-mags using the formula

Recovery of Proposed Young Star Binaries in Gaia DR2

$$V_{est} = 3.9379083526304 + 0.269235360436179 * Gmag^{1.36701081887491} - 0.123879978164097 * [Gmag - Rmag] - 0.943379695375539 * [Gmag - Bmag]$$

with a regression coefficient of 0.999 and a standard deviation of 0.064 derived by statistical analysis using nonlinear regression with the UBVRI catalogs of Landolt&Clem (VizieR II/183A, J/AJ/146/88 and J/AJ/152/91) after eliminating a few outliers due to questionable cross-match results with GAIA DR2. This estimation formula shares the photometry caveats of GAIA DR2 for very bright (<10Gmag) and very faint (>18Gmag) objects according to Evans et al. 2018 and Riello et al. 2018. In case of missing GAIA DR2 Bmag and Rmag data the visual magnitude was estimated with an average delta of +0.318 to Gmag.