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Semi-detached double-lined eclipsing binaries with Gaia DR3 data

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Abstract

Semi-detached double-lined eclipsing binaries (SD DLEB) play an important role in our understanding of basic properties of interacting binaries. We have collected data on semi-detached systems with available light and radial velocity curve solutions, and have compiled the most comprehensive list of SD DLEB, containing astrophysical and orbital parameters. The goal of this work was to make a cross-identification of the catalogued objects with Gaia DR3 archive. We have supplied our catalogue with data from Gaia DR3 as well as multicolor photometry from SIMBAD, and make a preliminary analysis of the results.

Keywords: *binaries: close – binaries: eclipsing – stars: evolution*

1. Introduction

Semi-detached eclipsing systems provide a unique opportunity to derive basic properties of interacting binaries. In our previous work we collected data on semi-detached systems with available light and radial velocity curve solutions, and compiled the most comprehensive list of SD DLEB, containing astrophysical and orbital parameters. We considered the classification of semi-detached binaries and discussed gaps between various classes in the HR diagram. We listed systems with component parameters that are inverted and briefly discussed their evolutionary state. A special analysis was conducted for systems with controversial data on parallaxes (Malkov (2020)). We compiled useful empirical relations between parameters of the accretor and the donor (Malkov (2021)). We also compared the catalogued data with models of low and intermediate-mass interacting binaries (Zeleke et al. (2022)).

In the present work we cross-identify a revised version of our catalogue with Gaia DR2/DR3 archives (Gaia Collaboration et al. (2016, 2022)), with the main purpose of providing the objects with triginometric parallax. We also supply our objects with multicolor photometry driven for SIMBAD database.

2. Cross-identification with Gaia DR3 and analysis of the results

Cross-identification of the catalogued objects with Gaia archive was carried out with the help of the service https://gea.esac.esa.int/archive/. Some special cases are described below.

Flamsteed identifier 68 Her was used for the star u Her in the current version of the catalogue. This is done so that the Gaia archive does not confuse it with another star, U Her.

The prototype of the class, β Per itself, was not found in the Gaia DR3 archive. It is included in Gaia DR2, however, parallax and proper motion are not measured by Gaia. The values, given in our catalogue, are taken from van Leeuwen (2007).

The only catalogued star with unknown parallax is GG Cas. It is included both in Gaia DR2 and DR3 archives, but the parallax is not determined. According to SIMBAD, ground based parallax for this star is also inavailable.

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The majority (105) of the catalogued objects are marked as variable in Gaia DR3. We did not find a dependence of the probability of recognising the star as a variable on the period or on other parameters. Apparently it should depend on the maximum amplitude.

According to the non-single-star flags, Gaia recognize two catalogued stars as spectroscopic binaries (flag=2), sixteen others as eclipsing binaries (flag=4), three others as eclipsing+spectroscopic binaries (flag=6), and the rest remain single (flag=1) or unclassifed stars. The stars with flag=6 (YY Cet, RW CrB, RZ Dra) are among the shortest period binaries in our sample, they all have period less than 0.8 day.

It is known that besides the data, based on the coordinates of the input object, Gaia DR3 archive also displays data (coordinates, parallax, proper motion, radial velocity) provided by the CDS Name resolver. The target-distance parameter, containing the on-sky angular separation (in units of degrees) between the target coordinates provided by the Name resolver and the target coordinates of the Gaia DR3 archive, is also calculated and provided. For the majority of the catalogued objects these two sets of parameters are the same, and target-distance does not exceed 1.5×10^{-8}. However, seven objects from our sample (QS Aql, AB Per, δ Pic, V Pup, λ Tau, GG Cas, IU Aur) demonstrate a suspiciously high value (5.8×10^{-6} to 1.5×10^{-5}) of target-distance and/or a large difference between parallaxes provided by the Name resolver and ones driven from the Gaia DR3 archive. Obviously in these cases one should rely upon the data, provided by the Name resolver. In fact, QS Aql, AB Per, δ Pic, V Pup, λ Tau are absent in Gaia DR3 archive (but they are included in Gaia DR2).

Consequently, for these five stars and for β Per Gaia DR2 names are included in the current version of the catalogue, rather than Gaia DR3 names. Also, parameters teff-val and a-g-val are taken for these stars from Gaia DR2 instead of teff-gspphot and ag-gspphot, provided by Gaia DR3.

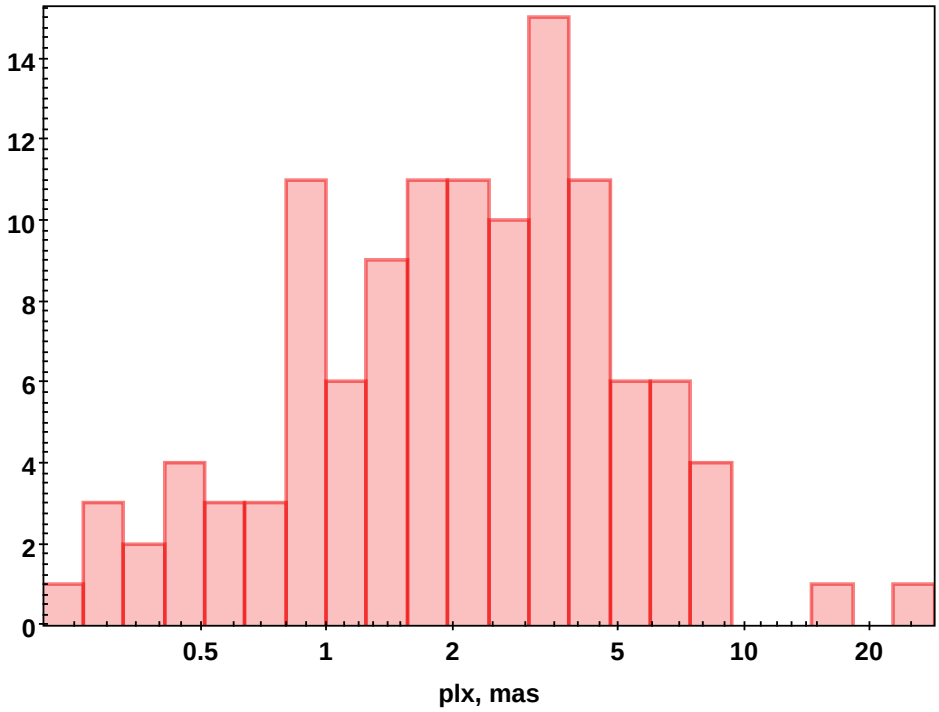

Figure 1. Distribution of the catalogued objects by parallax (target-parallax, see text for explanation). Two nearest objects are R CMa (ϖ= 23.16 mas) and RZ Cas (ϖ= 15.31 mas).

Distribution of the catalogued objects by target-parallax is shown in Fig. 1.

Position of the catalogued objects in the Hertzsprung-Russell diagram is shown in Fig. 2. B and V magnitudes are taken from SIMBAD, and absolute V-magnitude (M_V) is calculated from V and parallax; no correction for interstellar extinction is made.

3. Conclusion

Objects from a refined version of the Catalogue of semi-detached double-lined eclipsing binaries were cross-matched with Gaia DR3 archive (with the main purpose of providing the objects with triginometric parallax), and the results were analysed. Among 120 catalogued objects, two stars have no Gaia parallax.

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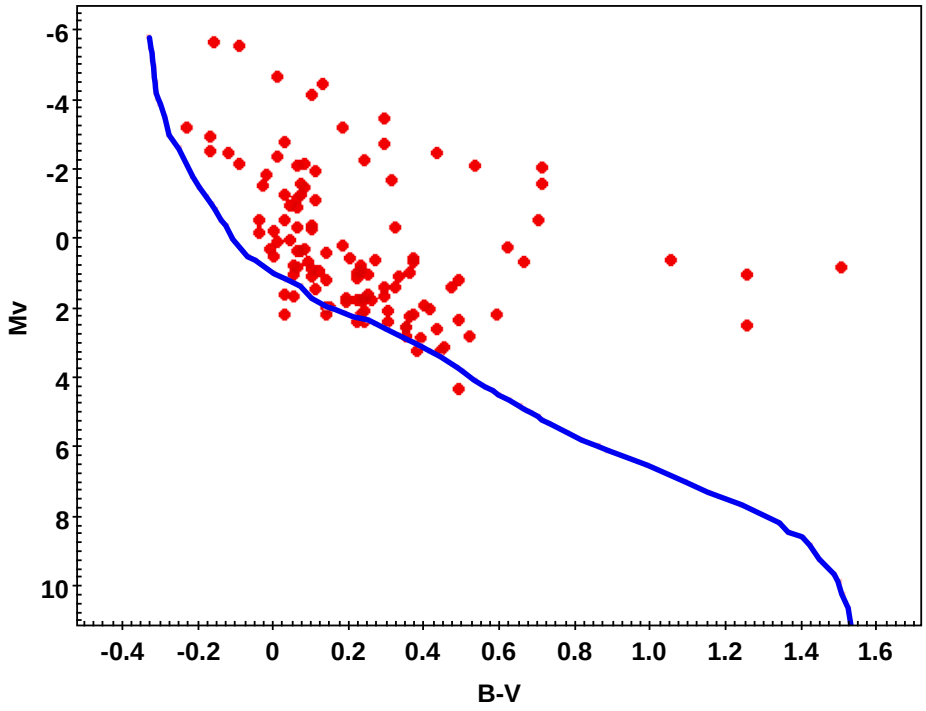

Figure 2. Catalogued objects in the Hertzsprung-Russell diagram (red points). M_V is calculated from V and parallax, no correction for interstellar extinction is made. $B-V$ is taken from SIMBAD. Blue curve represents the main sequence (see Mamajek's data available at http://www.pas.rochester.edu/~emamajek/EEM_dwarf_UBVIJHK_colors_Teff.txt and published in (Pecaut et al., 2012)).

GG Cas, being included both in Gaia DR2 and DR3 archives, has no parallax at all, while β Per, being included in Gaia DR2 archive but not in DR3 archive, has only Hipparcos parallax. Five more stars were not found in Gaia DR3, but present in Gaia DR2.

The majority of the catalogued stars remain single objects for Gaia DR3 from photometric and/or spectroscopic point of view. Shorter period systems ($P < 0.8$ day) have the best chance of being recognised as eclipsing+spectroscopic binary stars.

In addition, multicolor photometry from SIMBAD is added, and the Hertzsprung-Russell diagram of the catalogued objects is constructed.

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Appendices

Appendix A List of 120 semi-detached double-lined eclipsing binaries with Gaia and SIMBAD data

The table contains name, orbital period (in day), spectral type, Gaia DR2/DR3 ID, parallax with error (mas), G, B, V magnitudes, absolute V magnitude M_V. Not all parameters are shown in the table. Some values are rounded.

Table 1. Semi-detached binaries in Gaia archive

Name	P	Sp	Gaia ID	plx	plx er	G	B	V	Mv
TW And	4.1227	FV+KIV	2874199987159664384	3.8517	0.0282	9.0082	9.48	9.07	1.99
WW And	23.2852	A5+F3p	1926891142676374656	0.8376	0.0767	10.8320	11.44	11.07	0.68
RY Aqr	1.9665	A7+G8III	6892535685232812032	6.2888	0.0178	8.8099	9.26	8.87	2.86
XZ Aql	2.1391	A2	4216146640300354048	1.9380	0.0223	10.0654	10.43	10.18	1.61
KO Aql	2.8640	AV+[G8IV]	4503821320738678016	4.0808	0.0250	8.3135	8.51	8.4	1.45
QS Aql	2.5132	B5V+[A8IV]	5517171678268362880	1.4729	0.9233	5.9610	5.91	6.0	-5.54
V337 Aql	2.7338	B0V+B3V	4261802284445511808	0.5371	0.0216	8.5272	9.32	8.89	-2.45
TT Aur	1.3327	B2V+B4	188555356425677184	0.9153	0.0239	8.5869	8.67	8.6	-1.59
IM Aur	1.2472	B7V+A5V	211807141136171136	1.8746	0.0422	7.9879	8.07	8.11	-0.52
IU Aur	1.8114	O9.5V+B0.5IV-V	182856896896621952	-1.1878	0.3224	8.3034	8.57	8.39	-3.21
Y Cam	3.3056	A7V+gK5	1136680382131779584	1.2510	0.0140	10.4755	10.93	10.6	1.08
S Cnc	9.4845	B9.5V+G8IV	661017766324783360	2.9054	0.0311	8.2423	8.44	8.35	0.66
RZ Cnc	21.6429	K0-2III+K4	709587249372597760	2.6995	0.0222	8.7417	10.17	8.67	0.82
R CMa	1.1359	F1V+G8IV	3030977013710528768	23.1637	0.0814	5.6195	6.05	5.7	2.52
HH Car	3.2314	8V+BIII	5338423042200185472	0.2273	0.0146	10.2249	10.79	10.5	-2.71
QZ Car	5.9986	late-OV+O8III	5350346970905044480	0.7356	0.1086	6.2499	6.37	6.24	-4.42
RZ Cas	1.1952	A(2-3)V+K1IV	541801332594262912	15.3142	0.0259	6.2293	6.40	6.26	2.18
SX Cas	36.561	midB+K3III	420596084197761920	1.2557	0.0168	8.7538	9.67	8.97	-0.53
TV Cas	1.8125	B9V+G5IV	428246623544412416	4.1720	0.0205	7.2029	7.29	7.22	0.32
TW Cas	1.4283	B9V+F6IV	516316302333109248	3.4822	0.0247	8.3126	8.48	8.38	1.08
ZZ Cas	1.2435	B3+[B9]	430730248515346560	0.3228	0.0296	10.9492	11.10	10.79	-1.66
AQ Cas	11.7210	B0.5II-III+B3II	511009646904766336	0.3265	0.0107	9.9073	10.84	10.31	-2.11
GG Cas	3.7587	B5V+KIII-IV	413230043488454656			9.7578	10.70	10.03	
SV Cen	1.6585	B1V+B6.5III	5335388664983921024	0.3875	0.0283	9.0943	9.71	9.7	-2.35
BF Cen	3.6933	B7V+[A]	5335710886269762688	0.5606	0.0242	8.6047	8.51	8.48	-2.77
MP Cen	2.9934	B3+B6/7	5334906700945688448	0.3570	0.0148	10.0490	10.40	10.29	-1.94
V716 Cen	1.4900	B5.5V+A2V	5895765142704352640	3.9426	0.0532	6.0934	6.13	6.09	-0.93
U Cep	2.4930	B8Ve+G8IV	566936237123439360	5.1938	0.0238	6.9091	6.92	6.92	0.49
RS Cep	12.4200	AVe+G8III-IV	5568325498978979 84	1.0822	0.0204	10.1544	10.76	10.39	0.56
XX Cep	2.3373	A8V+K1IV	2016972824676318336	3.1342	0.0138	9.1332	9.47	9.18	1.66
XY Cep	2.7745	B8+G4	2211230514682716288	1.7797	0.0607	9.7904	10.43	9.94	1.19
XZ Cep	5.0972	BII+B2III	2224860133836098560	0.9586	0.0156	8.1451	9.22	8.51	-1.58
GT Cep	4.9087	B2V+A0IV	2213360032485424768	0.7995	0.0248	8.0550	8.49	8.25	-2.23
LZ Cep	3.0705	O9III+ON9.7V	2199161386015469312	0.9070	0.0524	5.4814	5.55	5.54	-4.67
YY Cet	0.7904	A8V+G2IV	5138409988587248896	1.8792	0.0184	10.6365	10.98	10.68	2.04
U CrB	3.4522	B6V+F8-GIII-IV	1277156564676743552	2.4859	0.0301	7.7809	7.79	7.83	-0.19
RW CrB	0.7264	A9V+[K1IV]	1272944026393513088	3.7501	0.0202	10.1402	10.67	10.22	3.09
AB Cru	3.4133	O8Vn	6071508298145817344	0.2973	0.0192	8.4991	8.59	8.49	-4.14
AI Cru	1.4177	B2IVe	6058510765049380096	0.4963	0.0212	9.6074	9.67	9.69	-1.83
SW Cyg	4.5731	A2Ve+[KI]	2082658577035787392	2.1113	0.0134	9.2604	9.57	9.35	0.97
WW Cyg	3.3177	B7V+[G0IV]	2074464462324115456	0.8268	0.0149	9.9862	10.16	10.1	-0.31
KU Cyg	38.4394	A7V+M2III	2084134705758394112	0.8439	0.0180	10.9972	11.70	11.04	0.67
V448 Cyg	6.5197	O9.5V+B1Ib	2059011376158159488	0.4784	0.0193	8.0259	8.45	8.16	-3.44
V548 Cyg	1.8052	AV+[K]	2137780359106512640	1.6809	0.0307	8.5322	8.71	8.61	-0.26
W Del	4.8061	B9.5Ve+G5IV	1812558769663138176	1.2537	0.0273	9.7321	9.89	9.81	0.30
AV Del	3.8534	F8	1751749213935107456	1.2178	0.0224	11.4667	12.36	11.77	2.19
Z Dra	1.3574	A5V+gK2	1074900468737991552	3.2042	0.0234	10.3786	11.11	10.67	3.19
RZ Dra	0.5508	A5V+K2IV	2157561187465024896	2.6096	0.0152	10.4037	10.55	10.31	2.39
TW Dra	2.8068	A6V+KIII	1640708022815757568	6.0571	0.0179	7.3932	7.75	7.46	1.37
AI Dra	1.1988	A0V+G4V	1413786483748744960	6.0080	0.0832	7.0939	7.18	7.13	1.02
OO Dra	1.2383	A4V	1079310648531984000	1.4474	0.0152	11.0420	11.42	11.39	2.19
S Equ	3.4360	B8V+G8IV-III	1734709738640800256	2.4961	0.0280	8.3479	8.43	8.37	0.35
TZ Eri	2.6061	A6V+KIV	3202234883261674368	3.3372	0.0236	9.5287	9.97	9.61	2.22
AS Eri	2.6641	A3V+[G6IV]	3249135719973670528	4.7505	0.0354	8.2548	8.49	8.3	1.68
RW Gem	2.8654	B5V+[F5]	3424637773136532224	0.9177	0.0426	9.5709	9.89	9.79	-0.39
RX Gem	12.2086	AVe+K2IV	937758765659068288	1.5332	0.0212	9.1586	9.42	9.24	0.16
RY Gem	9.3005	A2Ve+K2IV	3168597794613114240	2.3807	0.0257	8.6340	8.88	8.68	0.56
AF Gem	1.2435	B9V+GIV	3378297756072107392	0.9693	0.0266	10.6398	11.05	10.82	0.75
UX Her	1.5488	A3V+KIV	4502802210861958272	3.9608	0.0196	8.8560	9.12	8.97	1.95
AD Her	9.7665	A4V+K2	4530807837182604800	1.7738	0.0193	9.5517	10.08	9.72	0.96

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Table 2. Semi-detached binaries in Gaia archive (continued)

Name	P	Sp	Gaia ID	plx	plx er	G	B	V	Mv
68 Her	2.0510	B2.5V+B8IV	1334035606852913536	3.4356	0.1164	4.8159	4.63	4.8	-2.51
RX Hya	2.2816	A2V+G5IV	5756165167814720512	3.6326	0.0190	9.4405	9.78	9.56	2.36
SX Hya	2.8957	A3+[G9IV]	6178229164451588352	3.8830	0.0261	8.7134	9.09	8.83	1.77
TT Hya	6.9534	B9.5V+KIII-IV	3532612598122182272	5.2365	0.0287	7.2110	7.43	7.31	0.90
RT Lac	5.0739	G5IV+G9IV	1961028607902617216	5.3695	0.0150	8.6038	10.09	8.84	2.48
TW Lac	3.0374	A3+[KIV]	2006361437964416128	0.9231	0.0179	11.4418	11.90	11.85	1.67
Y Leo	1.6861	A5V+G9IV	645963390556163456	2.5167	0.0582	10.0209	10.31	10.07	2.07
T LMi	3.0198	A3V+G7IV	793600868428166912	1.2835	0.0339	10.8380	11.09	11.06	1.60
SS Lib	1.4379	A5+[F5]	6261900040823123584	1.9312	0.0147	10.3447	10.87	10.47	1.89
del Lib	2.3273	AV+[G5IV]	6332277920392457472	9.2824	0.4724	4.8772	4.93	4.93	-0.23
RW Mon	1.9060	B9V+[G7IV]	3326370605032161664	1.9843	0.0252	9.2772	9.38	9.32	0.80
TU Mon	5.0490	B3V+A5III	3080938169233453312	0.6955	0.0493	9.2859	9.21	9.24	-1.54
UX Mon	5.9044	A5+G2III	3042861291292225280	1.7989	0.0212	8.2635	8.74	8.42	-0.30
AR Mon	21.2081	K0+K3	3058418895491950336	2.2975	0.0264	8.3985	9.84	8.79	0.59
AU Mon	11.1130	B3Ve+F8III	3112305895950166784	1.1534	0.0369	8.2367	8.46	8.43	-1.25
FW Mon	3.8735	B5+[F2IV]	3043073462677166976	0.6062	0.0352	9.9080	10.08	9.97	-1.11
BP Mus	3.3204	A0.5/1.5V+G5III	5842184360518202880	1.7848	0.0159	10.0832	10.43	10.11	1.36
UU Oph	4.3968	AV+[G6IV]	6034454000384147072	0.9841	0.1073	10.2306	10.58	10.44	0.40
KZ Pav	0.9498	F0V+K1	6375292709353220992	8.8818	0.0198	7.7369	8.28	7.85	2.59
TY Peg	3.0922	A2+[G6IV]	2812756459901030528	1.4461	0.0270	10.2518	10.46	10.21	1.01
AQ Peg	5.5485	A2e+G5IV	1770170564888184704	1.2063	0.0201	10.3072	10.57	10.47	0.87
AT Peg	1.1460	A4V+[G8IV]	2722801840219112448	3.5751	0.0333	8.9415	9.21	9.02	1.78
DI Peg	0.7118	F4+K4	2813513473657289088	3.6634	0.6702	9.4460	10.00	9.51	2.32
RT Per	0.8494	F5V+G7IV	242962936981732608	5.1901	0.0188	10.3327	11.22	10.73	4.30
RW Per	13.1989	B9.6e+K2III-IV	229136921858228096	2.1630	0.0342	9.4959	10.19	9.72	1.39
RY Per	6.8635	B4V+F7III	438165588512859008	1.1025	0.0273	8.4580	8.69	8.63	-1.15
ST Per	2.6483	A3V+K1IV	143580413107943680	2.6899	0.0265	9.4909	9.83	9.61	1.75
AB Per	7.1602	A5V+[G9IV]	237076873279709184	-1.7937	0.6592	9.5248	10.10	9.72	3.19
DM Per	2.7277	B5V+A5III	457464770661735296	1.3117	0.0273	7.8909	8.03	7.95	-1.46
IZ Per	3.6876	B8V+A5IV	407553608544043520	0.9596	0.0466	7.9390	8.07	8.01	-2.07
bet Per	2.8673	B8V+K2IV	239863001382455424	36.27	1.4	4.3403	2.07	2.12	
del Pic	1.6725	B0.5+B0.5-3	5499415974230271488	1.9695	0.2022	5.0749	4.58	4.81	-3.19
Y Psc	3.7657	A3V+KIV	2758178523763705856	2.1968	0.0265	9.2869	9.62	9.4	1.10
V Pup	1.4544	B1V+B3	5517171678268362880	0.8945	0.7329	8.2493	4.24	4.41	-2.93
XZ Pup	2.1923	AV+[G2IV]	5699396282969664256	2.7172	0.0290	7.7676	7.88	7.84	0.01
U Sge	3.3806	B8V+G4III-IV	4516549576568929408	3.7591	0.0283	6.4794	6.61	6.58	-0.54
RS Sgr	2.4156	B5V+A2	4044610255085884800	2.2917	0.0977	6.0343	5.94	6.03	-2.16
XZ Sgr	3.2755	A3V+G5IV	4053182253880893824	5.2533	0.0341	8.7903	9.29	8.94	2.54
V356 Sgr	8.8961	B3V+A2II	4079974569075292032	1.4783	0.0289	6.9040	7.07	6.99	-2.16
V505 Sgr	1.1828	A2V+G5IV	6878492245987853568	8.6674	0.1446	6.6395	6.62	6.48	1.16
mu01 Sco	1.4462	B0V+B2V	5971289565647972608	1.8732	0.7354	3.0698	2.82	2.98	-5.65
U Sct	0.9549	F+[G7IV]	4102730405305344128	3.1540	0.0172	10.0876	10.81	10.29	2.78
RZ Sct	15.1902	B3Ib+F5IV	4156190653517727360	1.2160	0.0208	7.3003	8.24	7.53	-2.04
RW Tau	2.7688	B8V+KIV	163742260906017024	3.4691	0.0428	8.0243	8.13	8.08	0.78
HU Tau	2.0563	B8V+GIV	3411229847309096704	7.8722	0.0466	5.8619	5.83	5.84	0.32
V1251 Tau	18.8988	G8III+K1-2III	3282677181172799104	1.9869	0.0209	9.2640	10.80	9.55	1.04
lam Tau	3.9529	B3V+A4IV	3305012316783145728	8.2174	0.5324	3.3871	3.29	3.41	-2.44
X Tri	0.9715	A3V+G5IV	298268990328628224	4.7529	0.0420	8.8134	9.30	9.0	2.38
TX UMa	3.0633	B8V+F7IV	829685534384441344	4.1849	0.0841	6.9228	6.99	6.98	0.08
VV UMa	0.6873	A1V+[G5IV]	1024762227410763264	2.1769	0.0394	10.1370	10.42	10.28	1.96
IO UMa	5.5201	A3	1567133171450548480	3.5249	0.0680	8.1156	8.44	8.21	0.94
W UMi	1.7011	A3V+[G2IV]	1727726671573301120	2.4373	0.0168	8.5609	8.92	8.65	0.58
RU UMi	0.5249	F0V+[G8IV]	1686621699950649344	3.5335	0.0144	10.0314	10.39	10.04	2.78
S Vel	5.9336	A5V+[K4IV]	5423067604782946432	6.0632	0.0207	7.7048	8.05	7.81	1.72
UW Vir	1.8107	A4+[K3IV]	3511171223730060672	4.1013	0.0508	8.9400	9.36	9.13	2.19
UY Vir	1.9945	A7V+[G6IV]	3508999005366339200	6.8690	0.2053	7.9309	8.36	7.99	2.17
BD Vir	2.5485	A5+[KIV]	3604868379129516160	2.3171	0.0247	9.8015	10.18	9.95	1.77
DL Vir	1.3154	A3V+KIV	6293889335197400064	4.5204	0.1266	6.7795	7.61	6.99	0.26
Z Vul	2.4549	B3V-A2III	2023954311223665536	1.9243	0.0207	7.3716	7.40	7.33	-1.24
RS Vul	4.4776	B5V+G1III-IV	2022188873509795200	2.7974	0.0233	6.7802	6.91	6.85	-0.91