Double Star Photometry – March 2019

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Abstract: The WDS catalog contains per June 2019 about 148,500 objects. About 50,000 of these come with a magnitude for the primary with single digit precision indicating rather an estimation 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) 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 (too small separation, 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 the first 37 such objects from images taken end of March 2019 with V-filter to allow for visual magnitude measurement by differential photometry. All objects were additionally checked for potential gravitational relationship using GAIA DR2 parallaxes.

Introduction

With few exceptions one single image was taken for all selected WDS objects with iTelescope iT24 with V-filter and 20 seconds exposure time and the imaging conditions were despite several due to bad weather cancelled sessions overall quite favourable. The number of objects in this report is somewhat smaller than planned as in several cases the secondary was too faint to be resolved with 20 seconds exposure time – useful lesson for the next imaging sessions to use for objects expected to be fainter than 15 Vmag longer exposure times.

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.

Results of Photometry and Catalog Checking

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

WDS	=	WDS ID
Disc	=	Discoverer code
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

(Text continues on page 22)

WDS	Disc	C	RA	Dec	dRA	dDec	Sep	e_Sep	PA	e_PA	Mag	e_Mag	SNR	dVmag	Date	Notes
11401+3758	CBL 349		11 40 07.409	37 57 43.20	0.08	0.08	18.92309	0.11314	197.269	0.343	12.240	0.061	93.34	0.06	2019.24395	1)3)
			11 40 06.934	37 57 25.13							16.086	0.112	10.97			
11283+3144	CRB 89		11 28 15.738	31 43 46.94	0.05	0.05	25.30060	0.07071	12.405	0.160	11.356	0.050	186.80	0.05	2019.24104	1)3)
			11 28 16.164	31 44 11.65							16.243	0.098	12.41			
11472+3812	CRB 90		11 47 12.717	38 12 24.78	0.09	0.07	36.55991	0.11402	192.304	0.179	15.974	0.115	10.51	0.06	2019.24394	1)3)
			11 47 12.056	38 11 49.06							16.586	0.180	5.92			
11289+3206	CVR 614		11 28 53.718	32 06 21.27	0.04	0.04	28.12077	0.05657	130.734	0.115	15.850	0.086	13.87	0.04	2019.24110	1)3)
			11 28 55.395	32 06 02.92							16.614	0.297	3.21			
11346+4052	ES 1401		11 34 33.529	40 51 23.13	0.05	0.04	6.39762	0.06403	327.739	0.573	11.955	0.051	141.88	0.05	2019.24382	1)
			11 34 33.228	40 51 28.54							12.538	0.051	105.44			
11318+3513	FMR 101		11 31 49.191	35 13 07.30	0.08	0.09	7.28388	0.12042	145.461	0.947	16.313	0.115	10.03	0.05	2019.24392	1)3)
			11 31 49.528	35 13 01.30							16.342	0.220	4.58			
11460+3149	GIC 102		11 45 56.434	31 49 25.70	0.03	0.03	9.10242	0.04243	271.322	0.267	13.756	0.044	59.09	0.04	2019.24106	1)
			11 45 55.720	31 49 25.91							14.092	0.046	45.65			
11187+3759	GRV 833		11 18 44.768	37 59 28.05	0.10	0.11	33.45107	0.14866	343.599	0.255	11.324	0.051	107.95	0.05	2019.24377	1)
			11 18 43.969	38 00 00.14							11.785	0.051	91.84			
11266+3946	GRV 835		11 26 39.192	39 46 31.01	0.11	0.09	24.52560	0.14213	292.815	0.332	11.687	0.081	96.05	0.08	2019.24384	1)
			11 26 37.231	39 46 40.52							11.836	0.081	81.94			
11500+3612	GRV 842		11 50 01.071	36 12 16.83	0.08	0.08	31.55400	0.11314	357.340	0.205	10.623	0.031	183.84	0.03	2019.24392	1)
			11 50 00.950	36 12 48.35							10.775	0.031	166.02			
11280+3403	HJ 498		11 27 58.447	34 03 40.04	0.05	0.07	21.56549	0.08602	88.725	0.229	11.566	0.050	153.91	0.05	2019.24382	1)
			11 28 00.182	34 03 40.52							12.280	0.051	112.27			
11248+4128	HJ 2570	A	11 24 47.235	41 30 26.40	0.03	0.04	17.50494	0.05000	279.038	0.164	10.677	0.050	182.96	0.05	2019.24113	2)
		B	11 24 45.696	41 30 29.15							13.869	0.056	43.62			
11248+4128	HJ 2570	A	11 24 47.235	41 30 26.40	0.03	0.04	46.08922	0.05000	210.916	0.062	10.677	0.050	182.96	0.05	2019.24113	2)
		C	11 24 45.127	41 29 46.86							12.800	0.052	71.16			
12006+3954	HJ 2593		12 00 38.682	38 54 57.64	0.07	0.07	24.77786	0.09899	333.840	0.229	10.657	0.071	127.90	0.07	2019.24118	1)
			12 00 37.746	38 55 19.88							14.123	0.085	21.64			
11150+3501	KZA 12	A	11 15 02.819	35 01 03.52	0.04	0.04	34.95900	0.05657	20.896	0.093	12.141	0.051	95.82	0.05	2019.24110	2)
		B	11 15 03.834	35 01 36.18							14.661	0.065	25.98			

Table 1: Results for measured WDS objects

Table 1 continues on the next page.

WDS	Disc	C	RA	Dec	dRA	dDec	Sep	e_Sep	PA	e_PA	Mag	e_Mag	SNR	dVmag	Date	Notes
11152+3628	KZA 13		11 15 10.809	36 28 11.13	0.09	0.07	22.06597	0.11402	280.444	0.296	13.130	0.093	45.33	0.09	2019.24117	1) 3)
			11 15 09.010	36 28 15.13							15.163	0.125	12.10			
11152+3521	KZA 15	A	11 15 26.180	35 20 08.84	0.07	0.05	18.83778	0.08602	138.004	0.262	13.820	0.058	36.86	0.05	2019.24114	1)
		B	11 15 27.210	35 19 54.84							14.212	0.063	28.09			
11152+3521	KZA 15	A	11 15 26.180	35 20 08.84	0.07	0.05	18.91869	0.08602	352.119	0.261	13.820	0.058	36.86	0.05	2019.24114	1) 3)
		C	11 15 25.968	35 20 27.58							15.086	0.082	16.32			
12001+4107	LDS5212		12 00 11.131	41 05 27.05	0.05	0.05	7.22402	0.07071	172.989	0.561	14.428	0.066	38.96	0.06	2019.24105	1) 3)
			12 00 11.209	41 05 19.88							15.775	0.083	18.27			
11512+3708	NSN 50		11 51 11.989	37 07 49.24	0.13	0.08	4.20700	0.15264	10.979	2.078	11.871	0.050	212.14	0.05	2019.24391	1) 3) 4)
			11 51 12.056	37 07 53.37							16.458	0.228	4.39			
11507+3312	SKF 8		11 50 42.735	33 12 18.58	0.09	0.15	7.09669	0.17493	108.570	1.412	12.331	0.093	45.17	0.09	2019.24122	1) 5)
			11 50 43.271	33 12 16.32							12.208	0.093	47.46			
11478+3648	SKF2577		11 47 47.326	36 47 38.02	0.10	0.09	45.85906	0.13454	283.904	0.168	11.813	0.061	103.31	0.06	2019.24394	2)
			11 47 43.620	36 47 49.04							14.979	0.078	21.41			
11554+3919	SKF2579		11 55 26.264	39 19 19.62	0.14	0.12	6.51689	0.18439	342.059	1.621	12.519	0.072	64.04	0.07	2019.24380	2)
			11 55 26.091	39 19 25.82							12.731	0.073	56.02			
12010+4058	SKF2641		12 00 58.284	40 57 32.21	0.07	0.12	5.36533	0.13892	65.793	1.483	14.027	0.054	51.98	0.05	2019.24104	2)
			12 00 58.716	40 57 34.41							14.997	0.064	26.80			
11498+4024	SKF2692		11 49 50.775	40 24 14.47	0.11	0.09	77.68701	0.14213	27.390	0.105	10.233	0.060	186.54	0.06	2019.24379	2) 6)
			11 49 53.904	40 25 23.45							14.301	0.065	45.08			
11527+3937	SKF2693		11 52 44.348	39 36 38.05	0.12	0.13	12.38037	0.17692	4.014	0.819	12.800	0.091	85.35	0.09	2019.24383	2) 7)
			11 52 44.423	39 36 50.40							14.714	0.096	33.39			
11141+3926	SLW 580		11 14 03.465	39 25 34.09	0.06	0.06	32.19528	0.08485	50.012	0.151	16.386	0.141	8.35	0.07	2019.24108	1) 3)
			11 14 05.594	39 25 54.78							16.514	0.144	8.14			
12069+3921	SLW 684		12 06 52.633	39 20 58.10	0.03	0.04	8.28579	0.05000	19.717	0.346	15.918	0.092	15.10	0.06	2019.24101	1) 3)
			12 06 52.874	39 21 05.90							15.945	0.093	14.88			
11246+3752	UC 163		11 24 35.262	37 52 24.92	0.06	0.08	16.22781	0.10000	29.457	0.353	10.778	0.041	159.17	0.04	2019.24389	2)
			11 24 35.936	37 52 39.05							10.810	0.041	157.35			
11390+3253	UC 163		11 38 57.810	32 53 08.64	0.07	0.10	34.16630	0.12207	270.989	0.205	12.549	0.061	93.95	0.06	2019.24376	2)
			11 38 55.098	32 53 09.23							13.717	0.018	59.36			

Table 1 (continued). Results for measured WDS objects

Table 1 concludes on the next page.

WDS	Disc	C	RA	Dec	dRA	dDec	Sep	e_Sep	PA	e_PA	Mag	e_Mag	SNR	dVmag	Date	Notes
11281+3940	UC 2144		11 28 03.377	39 40 21.25	0.05	0.09	25.96301	0.10296	92.252	0.227	10.713	0.091	91.22	0.09	2019.24386	2)
			11 28 05.624	39 40 20.23							13.404	0.093	43.78			
11414+3624	UC 2190		11 41 23.277	36 23 31.45	0.15	0.11	11.02058	0.18601	169.329	0.967	11.761	0.061	84.87	0.06	2019.24396	1)3)
			11 41 23.446	36 23 20.62							14.610	0.091	15.26			
11431+4040	UC 2196		11 43 04.505	40 40 14.94	0.08	0.16	20.25504	0.17889	113.634	0.506	14.393	0.027	40.09	0.05	2019.24384	1)3)
			11 43 06.136	40 40 06.82							16.722	0.162	6.55			
11454+3856	UC 2205		11 45 25.135	38 56 12.46	0.06	0.06	33.13616	0.08485	12.506	0.147	13.997	0.046	46.10	0.04	2019.24393	1)3)
			11 45 25.750	38 56 44.81							15.818	0.083	14.45			
12019+4045	UC 2253		12 01 55.069	40 45 28.89	0.03	0.03	31.20611	0.04243	276.477	0.078	11.029	0.040	227.30	0.04	2019.24103	2)
			12 01 52.340	40 45 32.41							15.714	0.063	21.72			
11150+3501	WNO 35		11 15 02.821	35 01 03.50	0.06	0.06	31.24440	0.08485	165.728	0.156	12.156	0.051	103.61	0.05	2019.24112	1)3)
			11 15 03.448	35 00 33.22							15.551	0.083	15.97			

Table 1 (conclusion). Results for measured WDS objects

Talbe 1 Notes:

1) One image taken with iTelescope T24 with V-filter and 20 seconds exposure time
2) Two images taken with iTelescope T24 with V-filter and 20 seconds exposure time
3) SNR for A or B or both <20: Indicates that the Vmag measurement results might be a bit less precise than desired due to a low SNR value but this is already included in the calculation of the magnitude error range estimation
4) Overlapping star disks: Indicates that the star disks overlap to the degree of an elongation and that the measurement results is probably less precise than with clearly separated star disks
5) B seems to be an optical double, Vmag thus likely too bright
6) A is double itself
7) B is double itself

Object	Comp	PA	e_PA	Sep	e_Sep	Plx1	e_Plx1	Plx2	e_Plx2	Min_D_AU	Med_D_AU	Max_D_AU	LPGR
CBL 349		196.402	0.000	18.55914	0.00008	3.7158	0.0457	3.6504	0.0596	4921	1086968	5804054	9.58
CRB 89		12.503	0.000	25.25153	0.00013	3.3730	0.0755	3.1610	0.1033	7500	4089259	15619502	1.66
CRB 90		193.898	0.000	36.29887	0.00019	1.8739	0.1395	1.9167	0.0605	18056	6085613	58942228	1.79
CVR 614		130.743	0.000	27.91903	0.00010	2.4359	0.0491	2.3833	0.0884	11126	2756750	20310406	4.03
ES 1401		326.757	0.001	6.40594	0.00010	7.0785	0.0571	7.0926	0.0676	897	248338	1715373	41.19
FMR 101		143.896	0.001	7.38382	0.00011	8.1703	0.0774	8.3056	0.0869	892	419687	2039336	23.36
GIC 102		271.738	0.001	9.07326	0.00016	31.9093	0.0473	31.8181	0.1199	284	22454	157008	100.00
GRV 833		343.783	0.000	33.57743	0.00014	4.4512	0.0822	4.5259	0.0714	7288	941913	5823795	11.31
GRV 835		293.900	0.000	24.42271	0.00007	3.6815	0.0411	3.6886	0.0398	6539	590579	3871893	18.12
GRV 842		356.931	0.006	31.76644	0.00311	1.8447	0.8246						
HJ 498		88.363	0.000	21.41405	0.00011	3.5047	0.0627	4.3205	0.1057	3863988	11107893	18294413	0.00
HJ 2570	AB	279.188	0.000	17.61598	0.00006	3.2274	0.0509	0.2019	0.0249	588626193	957060342	1978988952	0.00
HJ 2570	AC	211.069	0.000	45.88431	0.00007	3.2274	0.0509	2.6416	0.0335	8275657	14165474	19917679	0.00
HJ 2593		332.966	0.000	25.03633	0.00006	4.2369	0.0439	0.9070	0.0277	151231586	178708930	216037356	0.00
KZA 12	AB	20.630	0.000	34.91873	0.00007	2.6797	0.0504	1.0246	0.0427	91648787	124296459	169923241	0.00
KZA 12	AC	215.953	0.000	43.76426	0.00007	2.6797	0.0504	1.3338	0.0416	57267221	77652259	106844634	0.00
KZA 13		280.573	0.000	21.96325	0.00009	1.3184	0.0521	1.1586	0.0531	17035	21543491	71113371	0.15
KZA 15	AB	138.168	0.000	18.84457	0.00006	1.9902	0.0415	2.2549	0.0443	385958	12181925	25175618	0.00
KZA 15	AC	352.488	0.000	19.02812	0.00007	1.9902	0.0415	1.2637	0.0591	31623109	59550076	109554970	0.00
LDS5212		171.832	0.000	7.22360	0.00006	7.7240	0.0319	7.6662	0.0494	932	211771	1049347	47.37
NSN 50		10.142	0.001	4.77175	0.00009	7.2536	0.0666	7.1711	0.0935	653	394037	2384315	26.69
SLW 580		50.394	0.000	31.99172	0.00011	3.5263	0.0749	3.4440	0.0806	8784	1638829	10305174	6.34
SLW 684		19.450	0.000	8.34125	0.00007	4.6031	0.0380	4.6768	0.0422	1768	715578	3044818	12.66
UC 163		29.473	0.000	16.27874	0.00008	4.0915	0.0682	3.2223	0.0712	5292104	13597107	20472816	0.00
UC 164		270.989	0.000	34.22015	0.00006	5.6205	0.0372	5.6331	0.0238	6037	201796	1318002	49.61
UC 2144		92.512	0.000	26.05041	0.00006	7.4464	0.0349	7.4163	0.0354	3477	148840	904244	63.66
UC 2190		170.715	0.000	11.34537	0.00006	5.6596	0.0530	5.5420	0.0380	2009	773474	2693529	7.82
UC 2196		112.689	0.000	20.47500	0.00011	2.2147	0.1038	1.8961	0.0502	10544	15642446	35926491	0.06
UC 2205		12.741	0.000	33.09966	0.00008	25.5666	0.0579	25.4984	0.0502	1292	23432	122543	100.00
UC 2253		276.525	0.000	31.19689	0.00006	11.2609	0.0385	11.0959	0.0534	2781	272109	741915	25.39
WNO 35		165.930	0.000	31.36745	0.00008	2.6797	0.0504	0.6600	0.0510	154553143	235644851	382942367	0.00

Table 2: Results for cross-matched objects

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(Continued from page 17)

Cross-Match with GAIA DR2

All listed objects were additionally cross-matched with GAIA DR2 to check for potential gravitational relationship (PGR) – the results are given in Table 2 with the following structure:

Object	=	Discoverer ID
Comp	=	Components (AB if blank)
PA	=	Position angle in degrees
e_PA	=	Error position angle
Sep	=	Separation in arcseconds
e_Sep	=	Error separation
Plx1	=	Parallax 1 in mas
e_Plx1	=	Error parallax1
Plx2	=	Parallax 2 in mas
e_Plx2	=	Error parallax 2
Min_D_AU	=	Minimum spatial distance in AU between components (see Appendix)
Med_D_AU	=	Median spatial distance in AU between components (see Appendix)
Max_D_AU	=	Maximum spatial distance in AU between components (see Appendix)
LPGR	=	Likelihood of potential gravitational relationship (see Appendix)

To avoid redundant reporting some objects were deleted in Table 2 if already cross-matched with GAIA DR2 in other reports. For the objects UC 2205, UC 2144 and GIC 102 WDS code "T" is suggested for likely physical by common parallaxes. For the objects with LPGR <10 WDS code "U" for likely optical is suggested.

Summary

A good part of the 37 measured objects shows 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. 3 objects have parallaxes and angular separations allowing for a higher than 50% likelihood for a spatial distance between the components of less than 200,000 AU (~1 parsec) suggesting potential gravitational relationship.

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

References

Knapp, Wilfried R. A., 2018, "A New Concept for Counter-Checking of Assumed Binaries", *Journal of Double Star Observations*, **14** (3), 487-491.

Appendix

Description of the PGR assessment procedure

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 spatial distance between the components is (according to Knapp 2018) calculated from the inverted simulated parallax data and the simulated angular separation using the law of cosine

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

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 likelihood for potential gravitational relationship (LPGR) is the percentage of simulation results <200,000 AU (~1 parsec) out of the simulation sample with a size of 120,000

The given smallest, median and largest spatial distance between the components is the smallest, median and largest result out of the simulation sample.