Jonckheere Double Star Photometry – Part XIV

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Abstract: If any double star discoverer is in urgent need of photometry then it is Jonckheere. There are over 3000 Jonckheere objects listed in the WDS catalog and a good part of them with magnitudes obviously far too bright. This report covers the Jonckheere objects in the constellations Pup, Pyx and partly Mon. One image per object was taken with V-filter to allow for visual magnitude measurement by differential photometry. All objects were additionally checked for potential gravitational relationship.

Preamble: This report in no way intends to belittle the work of Jonckheere – on the contrary: He was obviously a very dedicated and able double star observer fighting with a lot of obstacles up to equipment destroyed in war. It seems that the basic double star parameters, RA/Dec coordinates and separation as well as position angle were his main concern and the estimation of magnitudes was rather a side aspect to him. The often crass over estimation of magnitudes may also be a side effect of his obviously extraordinary eyesight.

1. Introduction

As follow up to the reports on J-objects photometry beginning with Knapp/Nanson 2016 this report covers the J-objects in the constellations Pup, Pyx and to some degree in Mon. The plan to cover the rest of J-objects in Mon after the Mon I report in JDSO 14/4 failed due to repeated weather conditions unsuitable for imaging. Imaging sessions were rescheduled several times and images from seemingly successful sessions had to be dismissed due to poor quality. Usually even low quality images provide still useful differential photometry results but in this case I got the impression that the existing material provides mostly Vmag measurements of little value – so only a fraction of the existing Mon image material was used for this report restricted to objects with current WDS Vmag values obviously in very great need of improvement.

The prospect to wait for another year to get a chance to complete the necessary imaging sessions in Mon led to the decision to quit the plan of covering all J -objects by constellations. For this reason this is my last report on Jonckheere objects photometry covering so far in total about 30% of all J-objects - but I intend to continue with photometry reports for WDS objects in need of precise Vmag photometry regardless of discoverer.

2. Results of Photometry and Catalog Checking

For all selected J-objects one single image was taken with iTelescope iT24 or iT27 with V-filter and 3s exposure time. Astrometry results based on one single image have to be taken with caution beyond the given error range but this aspect seems less significant for the V-filter measured magnitudes as a magnitude error of ~0.1 or even a bit larger seems negligible in comparison with those of many Jonckheere objects, which often have given magnitude errors in the range of up to 2 or more magnitudes.

The images were plate solved with Astrometrica using the URAT1 or UCAC4 catalog with reference stars in the Vmag range of 8.5 to 14.5 giving not only RA/Dec coordinates but also photometry results for all reference stars used including an average dVmag error. The J-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.

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

- J#: number of J-object
- C: components
- 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 using the given positions
- e_Sep: separation error
- PA: calculated position angle in degrees using the given positions
- e_PA: position angle error
- Mag: Vmags for both components measured by differential photometry
- e_Mag: magnitude error
- SNR: signal to noise ratio of the image used for plate solving
- dVmag: plate solving error in Vmag
- Date: Julian observation epoch
- Notes: telescope used with exposure time or reference to additional comments listed below Table 1

All listed objects were additionally checked for being potential physical by cross-matching with GAIA DR2 using proper motion and parallax data if available. The results are listed in table 2 below with the following structure:

- J#: number of J-object
- C: components (AB if blank)
- PA: calculated epoch 2015.5 position angle in degrees
- e_PA: position angle error
- Sep: calculated epoch 2015.5 separation in arcseconds
- e_Sep: separation error
- Vest1/2: estimated Vmags from GAIA G/R/B-mags (see Appendix)
- e_Vest1/2: estimated Vmag error
- pmRA/DE/1/2: GAIA DR2 proper motion values
- CPMS: Common proper motion score (estimated likelihood for common proper motion)
- Plx1/2: GAIA DR2 parallax values
- e_Plx1/2: GAIA DR2 parallax error values
- PGRS: potential gravitational relationship score (estimated likelihood for potential gravitational relationship (see Appendix)

Summary

Most of the listed J-objects in Pup, Mon and Pyx show the expected magnitude difference larger than 0.5 compared with the WDS catalog data. Only 4 of these objects qualify as solid or at least good CPM candidates based on a rating scheme using GAIA DR2 proper motion data if available for both components with the caveat of rather small proper motion values for most of them. Finally only J 2638BC has parallax and angular separation values allowing for a 100% likelihood for a distance between the components of less than 200,000 AU suggesting potential gravitational relationship between the components which means WDS notes code "T". While several of the other listed objects have very similar parallax values for both components these parallax values are far too small to allow for a noticeable likelihood for being physical as the possible distances between the components increases in such cases exponentially even within a small parallax error range (Knapp 2019). So all of the listed objects with exception of J 2638BC are most likely optical pairs.

A comparison of estimated Vmags calculated from GAIA DR2 G/R/B-mags with the results from differential photometry shows a mean difference of -0.090 and a standard deviation of 0.236 – this indicates a small bias for Vmag estimations slightly fainter compared to differential photometry measurement results with a standard deviation mostly caused by the average plate solving dVmag errors. The correlation coefficient between measured and estimated Vmags with 0.986 allows for the conclusion that the estimated Vmags are a useful substitute in cases of lacking Vmag measurements.

Acknowledgements:

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

- Washington Double Star Catalog
- CDS VizieR
- GAIA DR2 catalog
- DSS and 2MASS images
- Aladin Sky Atlas v10.0
- iTelescope
- iT24: 610mm CDK with 3962mm focal length. CCD: FLI PL09000. Resolution 0.62 arcsec/pixel. V-filter. Located in Auberry, California. Elevation 1405m
- iT27: 700mm CDK with 4531mm focal length. CCD: FLI PL09000. Resolution 0.53 arcsec/

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Table 1: Photometry results for measured J objects

J#	C	RA	Dec	dRA	dDec	Sep	e_Sep	PA	e_PA	Mag	e_Mag	SNR	dVmag	Date	Notes
1493	A	07 32 05.119	-12 16 24.94	0.06	0.06	6.72113	0.08485	75.525	0.723	10.884	0.080	144.68	0.08	2016.10968	iT27 1x3s
	B	07 32 05.563	-12 16 23.26							11.066	0.080	127.00			
1497	A	07 33 53.509	-11 23 21.95	0.07	0.07	8.27451	0.09899	58.933	0.685	11.029	0.081	97.31	0.08	2016.10968	iT27 1x3s
	B	07 33 53.991	-11 23 17.68							12.446	0.082	63.84			
1505	A	07 56 39.184	-23 30 09.83	0.06	0.07	6.33445	0.09220	258.342	0.834	9.763	0.080	241.59	0.08	2016.10972	iT27 1x3s
	B	07 56 38.733	-23 30 11.11							11.892	0.081	91.11			
1506	A	07 58 54.559	-24 38 57.27	0.07	0.07	7.17486	0.09899	86.004	0.790	10.732	0.080	177.66	0.08	2016.10972	iT27 1x3s
	B	07 58 55.084	-24 38 56.77							11.781	0.081	115.69			
1507	A	08 02 32.861	-24 47 07.28	0.07	0.07	7.10971	0.09899	323.026	0.798	9.654	0.080	198.26	0.08	2016.10971	iT27 1x3s
	B	08 02 32.547	-24 47 01.60							11.128	0.080	130.56			
1509	A	08 11 07.464	-21 07 09.93	0.07	0.08	6.01542	0.10630	266.283	1.012	11.210	0.081	96.89	0.08	2016.10968	iT27 1x3s
	B	08 11 07.035	-21 07 10.32							12.495	0.083	47.05			
1509	A	08 11 07.464	-21 07 09.93	0.07	0.08	16.40414	0.10630	337.269	0.371	11.210	0.081	96.89	0.08	2016.10968	iT27 1x3s
	C	08 11 07.011	-21 06 54.80							12.664	0.082	58.96			
1510	A	08 13 12.062	-12 27 06.67	0.06	0.07	3.54930	0.09220	262.065	1.488	10.465	0.071	92.60	0.07	2016.10964	iT27 1x3s
	B	08 13 11.822	-12 27 07.16							11.311	0.073	52.21			
1519	A	08 24 40.788	-18 31 20.28	0.07	0.08	5.79216	0.10630	321.771	1.051	10.883	0.081	102.47	0.08	2016.10965	iT27 1x3s
	B	08 24 40.536	-18 31 15.73							11.185	0.081	87.89			
2041	A	07 35 45.384	-11 43 12.59	0.08	0.08	6.27458	0.11314	336.405	1.033	11.383	0.081	96.40	0.08	2016.10968	iT27 1x3s
	B	07 35 45.213	-11 43 06.84							11.884	0.081	73.70			
2041	A	07 35 45.384	-11 43 12.59	0.08	0.08	17.66848	0.11314	306.099	0.367	11.383	0.081	96.40	0.08	2016.10968	iT27 1x3s
	C	07 35 44.412	-11 43 02.18							12.580	0.082	59.03			
2048	A	07 51 46.554	-16 44 15.95	0.07	0.07	5.38181	0.09899	350.630	1.054	11.212	0.071	127.57	0.07	2016.10969	iT27 1x3s
	B	07 51 46.493	-16 44 10.64							11.770	0.071	83.91			
2049	A	07 57 46.742	-16 00 19.79	0.07	0.08	5.38238	0.10630	194.109	1.131	12.873	0.082	60.67	0.08	2016.10967	iT27 1x3s
	B	07 57 46.651	-16 00 25.01							14.054	0.087	30.33			
2049	A	07 57 46.742	-16 00 19.79	0.07	0.08	9.45945	0.10630	270.787	0.644	12.873	0.082	60.67	0.08	2016.10967	iT27 1x3s
	C	07 57 46.086	-16 00 19.66							14.270	0.087	30.45			
2050	A	07 58 20.815	-11 57 56.96	0.08	0.08	6.95458	0.11314	333.428	0.932	10.966	0.071	121.22	0.07	2016.10966	iT27 1x3s
	B	07 58 20.603	-11 57 50.74							12.983	0.073	54.07			
2052	A	08 05 26.049	-12 34 35.86	0.06	0.07	4.18656	0.09220	183.207	1.262	11.169	0.071	105.87	0.07	2016.10965	iT27 1x3s
	B	08 05 26.033	-12 34 40.04							12.805	0.073	48.78			
2052	A	08 05 26.049	-12 34 35.86	0.06	0.07	20.52456	0.09220	228.500	0.257	11.169	0.071	105.87	0.07	2016.10965	iT27 1x3s
	C	08 05 24.999	-12 34 49.46							13.908	0.075	38.57			

Table 1 continues on the next page.

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Table 1 (continued): Photometry results for measured J objects

J#	C	RA	Dec	dRA	dDec	Sep	e_Sep	PA	e_PA	Mag	e_Mag	SNR	dVmag	Date	Notes
2053	A	08 05 23.270	-16 53 20.29	0.08	0.08	4.80075	0.11314	31.347	1.350	12.307	0.082	59.94	0.08	2016.10967	iT27 1x3s
	B	08 05 23.444	-16 53 16.19							13.188	0.084	44.17			
2056	A	08 17 43.301	-12 14 30.20	0.07	0.07	3.52435	0.09899	22.757	1.609	13.113	0.074	42.67	0.07	2016.10964	iT27 1x3s
	B	08 17 43.394	-12 14 26.95							12.883	0.074	47.08			
2058	A	08 24 36.981	-17 30 38.60	0.06	0.08	6.76697	0.10000	328.666	0.847	13.146	0.087	31.86	0.08	2016.10965	iT27 1x3s
	B	08 24 36.735	-17 30 32.82							13.402	0.088	29.73			
2479	A	07 31 03.427	-12 25 33.69	0.07	0.07	5.93364	0.09899	274.156	0.956	13.037	0.072	59.51	0.07	2016.10969	iT27 1x3s
	B	07 31 03.023	-12 25 33.26							13.326	0.073	48.04			
2480	A	07 31 08.805	-12 27 04.55	0.06	0.07	7.65420	0.09220	237.966	0.690	10.594	0.070	134.48	0.07	2016.10970	iT27 1x3s
	B	07 31 08.362	-12 27 08.61							13.024	0.073	52.89			
2480	A	07 31 08.805	-12 27 04.55	0.06	0.07	5.65756	0.09220	315.859	0.934	10.594	0.070	134.48	0.07	2016.10970	iT27 1x3s
	B	07 31 08.536	-12 27 00.49							13.396	0.078	30.37			
2481	A	07 32 51.789	-12 33 02.38	0.07	0.07	5.36726	0.09899	256.203	1.057	12.313	0.071	76.23	0.07	2016.10969	iT27 1x3s
	B	07 32 51.433	-12 33 03.66							13.621	0.075	38.07			
2481	A	07 32 51.789	-12 33 02.38	0.07	0.07	10.70234	0.09899	72.209	0.530	12.313	0.071	76.23	0.07	2016.10969	iT27 1x3s
	B	07 32 52.485	-12 32 59.11							13.744	0.080	27.75			
2489	A	07 53 08.249	-12 47 58.25	0.07	0.08	3.84023	0.10630	21.214	1.586	10.366	0.081	74.06	0.08	2016.10966	iT27 1x3s
	B	07 53 08.344	-12 47 54.67							11.398	0.084	40.83			
2490	A	07 56 47.471	-18 40 23.37	0.07	0.07	5.88230	0.09899	189.595	0.964	11.219	0.070	130.86	0.07	2016.10970	iT27 1x3s
	B	07 56 47.402	-18 40 29.17							11.979	0.071	88.37			
2633	A	07 30 40.661	-14 03 48.25	0.07	0.07	5.59821	0.09899	293.810	1.013	11.380	0.071	128.75	0.07	2016.10970	iT27 1x3s
	B	07 30 40.309	-14 03 45.99							11.699	0.071	102.43			
2635	A	07 51 45.238	-18 09 28.26	0.06	0.07	9.03741	0.09220	287.716	0.584	10.380	0.080	168.74	0.08	2016.10970	iT27 1x3s
	B	07 51 44.634	-18 09 25.51							12.476	0.081	70.85			
2638	A	08 10 21.327	-18 11 30.71	0.07	0.07	79.64168	0.09899	98.179	0.071	8.366	0.070	235.37	0.07	2016.10966	iT27 1x3s
	B	08 10 26.859	-18 11 42.04							12.856	0.017	64.72			
2638	B	08 10 26.859	-18 11 42.04	0.07	0.07	4.99265	0.09899	6.556	1.136	12.856	0.072	64.72	0.07	2016.10966	iT27 1x3s
	C	08 10 26.899	-18 11 37.08							13.634	0.074	44.67			
2639	A	08 10 25.117	-18 46 03.68	0.07	0.08	49.74785	0.10630	268.802	0.122	10.410	0.080	132.45	0.08	2016.10967	iT27 1x3s
	B	08 10 21.615	-18 46 04.72							13.147	0.083	45.71			
2639	B	08 10 21.615	-18 46 04.72	0.07	0.08	5.90116	0.10630	65.470	1.032	13.147	0.023	45.71	0.08	2016.10967	iT27 1x3s
	C	08 10 21.993	-18 46 02.27							13.357	0.083	46.02			
2838	A	07 35 09.517	-16 37 56.77	0.07	0.07	6.89338	0.09899	57.832	0.823	10.710	0.070	151.90	0.07	2016.10971	iT27 1x3s
	B	07 35 09.923	-16 37 53.10							12.320	0.071	81.35			

Table 1 continues on the next page.

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Table 1 (continued): Photometry results for measured J objects

J#	C	RA	Dec	dRA	dDec	Sep	e_Sep	PA	e_PA	Mag	e_Mag	SNR	dVmag	Date	Notes
2875	A	08 15 20.453	-11 26 44.54	0.07	0.08	5.82608	0.10630	207.666	1.045	11.174	0.070	129.66	0.07	2016.10963	iT27 1x3s
	B	08 15 20.269	-11 26 49.70							12.581	0.072	57.59			
2876	A	08 21 12.707	-13 33 48.14	0.07	0.08	5.23582	0.10630	153.360	1.163	11.098	0.070	133.68	0.07	2016.12070	iT27 1x3s
	B	08 21 12.868	-13 33 52.82							11.758	0.071	95.20			
2876	A	08 21 12.707	-13 33 48.14	0.07	0.08	13.37432	0.10630	37.080	0.455	11.098	0.070	133.68	0.07	2016.12070	iT27 1x3s
	C	08 21 13.260	-13 33 37.47							11.388	0.070	129.04			
261	A	06 27 20.546	07 47 50.55	0.10	0.10	3.31243	0.14142	102.023	2.445	10.674	0.151	55.02	0.15	2019.00576	iT24 1x3s. SNR B <20
	B	06 27 20.764	07 47 49.86							12.145	0.179	10.54			
277	A	06 57 11.929	06 55 49.97	0.11	0.10	7.53963	0.14866	6.578	1.130	9.861	0.131	81.31	0.13	2019.00580	iT24 1x3s. SNR B <20
	B	06 57 11.987	06 55 57.46							13.501	0.155	12.44			
356	A	07 00 03.959	-03 18 25.52	0.08	0.11	6.50076	0.13601	219.308	1.199	9.671	0.161	54.94	0.16	2018.94546	iT24 1x3s
	B	07 00 03.684	-03 18 30.55							11.705	0.169	19.71			
664	A	06 34 36.771	05 35 41.56	0.11	0.11	3.61360	0.15556	202.851	2.465	12.659	0.129	15.68	0.11	2018.94552	iT24 1x3s. SNR A and B <20
	B	06 34 36.677	05 35 38.23							13.240	0.151	10.05			
1486		07 07 22.652	-08 46 45.07	0.10	0.08	9.45001	0.12806	179.910	0.776	11.720	0.144	32.01	0.14	2018.95094	iT24 1x3s
		07 07 22.653	-08 46 54.52							11.902	0.145	27.32			
1974	A	06 48 44.430	08 44 27.04	0.08	0.10	3.88570	0.12806	40.152	1.888	13.075	0.210	8.32	0.17	2018.95101	iT24 1x3s. SNR A <10 and B <5
	B	06 48 44.599	08 44 30.01							14.470	0.310	3.70			
1981	A	06 57 06.795	06 32 08.80	0.09	0.11	7.62369	0.14213	112.683	1.068	12.607	0.157	23.46	0.15	2018.95102	iT24 1x3s. SNR B <20
	B	06 57 07.267	06 32 05.86							12.752	0.162	17.02			
1982	A			0.09	0.10		0.13454						0.15	2018.95103	1)
	B														
2460	A	07 16 51.154	-05 10 40.70	0.11	0.12	6.01024	0.16279	333.741	1.551	12.147	0.092	23.55	0.08	2019.07389	iT24 1x3s
	B	07 16 50.976	-05 10 35.31							12.306	0.090	25.55			
2485	A	07 41 36.573	-10 43 28.06	0.11	0.11	6.61999	0.15556	131.772	1.346	12.788	0.079	29.95	0.07	2019.07392	iT24 1x3s. SNR B <20
	B	07 41 36.908	-10 43 32.47							13.879	0.109	12.54			
2618	A	06 57 55.178	05 44 53.11	0.10	0.10	6.33283	0.14142	292.858	1.279	10.603	0.081	82.55	0.08	2019.07396	iT24 1x3s
	B	06 57 54.787	05 44 55.57							11.914	0.086	34.04			
2632	A	07 27 09.724	-05 34 40.78	0.10	0.09	34.07951	0.13454	71.754	0.226	9.307	0.071	80.18	0.07	2019.07397	iT24 1x3s
	B	07 27 11.892	-05 34 30.11							12.639	0.085	21.92			
2751	A	06 44 43.895	02 23 10.55	0.10	0.10	5.65217	0.14142	136.207	1.433	12.581	0.086	34.00	0.08	2019.07400	iT24 1x3s. SNR B <20
	B	06 44 44.156	02 23 06.47							13.884	0.116	12.47			

Table 1 concludes on the next page.

Table 1 (conclusion): Photometry results for measured J objects

J#	C	RA	Dec	dRA	dDec	Sep	e_Sep	PA	e_PA	Mag	e_Mag	SNR	dVmag	Date	Notes
2778	A	07 05 30.154	05 22 25.41	0.12	0.08	5.82443	0.14422	308.553	1.418	10.720	0.121	68.71	0.12	2019.14769	2)
	B	07 05 29.849	05 22 29.04							11.494	0.124	35.87			
2811	A	07 20 51.278	-01 31 22.54	0.10	0.10	7.45939	0.14142	156.295	1.086	11.371	0.151	55.23	0.15	2019.14773	iT24 1x3s
	B	07 20 51.478	-01 31 29.37							13.371	0.159	20.18			
2824	A	07 28 00.425	-04 45 01.25	0.11	0.09	5.38758	0.14213	99.940	1.511	11.196	0.153	34.36	0.15	2019.14776	iT24 1x3s. SNR B <10
	B	07 28 00.780	-04 45 02.18							13.427	0.261	4.59			
1522	A	08 28 34.969	-19 08 45.47	0.07	0.09	8.79439	0.11402	10.397	0.743	10.917	0.061	120.67	0.06	2016.12343	iT27 1x3s
	B	08 28 35.081	-19 08 36.82							11.903	0.061	90.88			
1524	A	08 31 12.586	-19 36 42.58	0.05	0.08	6.07998	0.09434	318.165	0.889	11.596	0.082	64.10	0.08	2016.12341	iT27 1x3s
	B	08 31 12.299	-19 36 38.05							11.652	0.082	62.91			
1524	A	08 31 12.586	-19 36 42.58	0.05	0.08	13.05790	0.09434	218.636	0.414	11.596	0.082	64.10	0.08	2016.12341	iT27 1x3s
	C	08 31 12.009	-19 36 52.78							13.489	0.087	30.16			
1526	A	08 35 08.573	-29 21 27.31	0.08	0.08	7.36512	0.11314	357.864	0.880	11.586	0.071	95.09	0.07	2016.12344	iT27 1x3s
	B	08 35 08.552	-29 21 19.95							12.153	0.072	71.51			
1527	A	08 35 57.718	-20 04 50.85	0.07	0.08	6.63478	0.10630	334.331	0.918	8.818	0.071	126.44	0.07	2016.12341	iT27 1x3s
	B	08 35 57.514	-20 04 44.87							10.821	0.072	72.55			
1529	A	08 39 30.343	-28 52 18.54	0.09	0.08	8.28491	0.12042	130.585	0.833	11.672	0.071	74.82	0.07	2016.12343	iT27 1x3s
	B	08 39 30.822	-28 52 23.93							12.113	0.072	63.00			
1531	A	08 45 39.380	-21 23 22.13	0.07	0.08	7.82122	0.10630	14.267	0.779	10.567	0.070	152.43	0.07	2016.12343	iT27 1x3s
	B	08 45 39.518	-21 23 14.55							10.883	0.070	139.55			
1532	A	08 49 33.845	-20 55 39.53	0.07	0.08	10.18146	0.10630	197.126	0.598	11.757	0.071	92.98	0.07	2016.12342	iT27 1x3s
	B	08 49 33.631	-20 55 49.26							12.322	0.071	77.99			
1541	A	09 09 42.714	-20 41 43.12	0.07	0.07	7.17334	0.09899	289.462	0.791	10.899	0.071	124.47	0.07	2016.12340	iT27 1x3s
	B	09 09 42.232	-20 41 40.73							12.235	0.071	75.21			
2061	A	08 39 57.204	-18 03 21.09	0.07	0.08	5.54347	0.10630	29.600	1.099	12.369	0.072	58.29	0.07	2016.12341	iT27 1x3s
	B	08 39 57.396	-18 03 16.27							13.603	0.081	26.60			
2645	A	08 41 45.359	-20 18 43.88	0.08	0.08	6.98177	0.11314	306.880	0.928	11.343	0.071	114.52	0.07	2016.12342	iT27 1x3s
	B	08 41 44.962	-20 18 39.69							11,810	0,071	98,03			

Notes:

1. J 1982: iT24 1x3s. No resolution of neither A nor B - faintest resolved star in this image is 13.9mag, thus both components have to be fainter than 14mag corresponding also with estimated Vmags from GAIA G/B/R values (see Table 2)
2. J 2778: iT24 1x3s. WDS position wrong. J 2778 is ident with AHD 36

Jonckheere Double Star Photometry – Part XIV

Table 2: Gaia DR2 Cross-Match Results for Listed J Objects

J#	C	PA	e_PA	Sep	e_Sep	Vest1	e_Vest1	Vest2	e_Vest2	pmRA1	pmDE1	pmRA2	pmDE2	CPMS	Plx1	e_Plx1	Plx2	e_Plx2	PGRS
1493		75.439	0.001	6.73305	0.00007	11.031	0.001	11.221	0.001	10.500	-27.317	11.159	-27.787	39	3.7112	0.0552	3.6657	0.0408	12
1497		58.790	0.001	8.18258	0.00009	11.038	0.003	12.381	0.002	-3.917	0.530	-3.218	-1.515	0	0.4533	0.0498	1.3275	0.0709	0
1505		258.140	0.000	6.34048	0.00004	10.088	0.001	11.981	0.007	17.164	-18.819	16.820	-21.315	0	5.2322	0.0323	5.3051	0.0336	14
1506		85.909	0.000	7.17996	0.00005	11.025	0.001	11.930	0.002	-4.902	7.626	-4.980	7.648	97	0.5349	0.0307	0.5498	0.0328	1
1507		323.099	0.000	7.10507	0.00005	10.054	0.002	11.135	0.002	-1.317	-0.477	-5.959	3.092	0	1.1838	0.0372	0.9852	0.0402	0
1509		265.280	0.001	5.99852	0.00007	11.243	0.002	12.377	0.004	-8.644	0.001	-8.395	-0.009	39	1.3906	0.0619	1.3398	0.0349	2
1509	AC	337.555	0.000	16.34125	0.00006	11.243	0.002	12.681	0.001	-8.644	0.001	-1.293	-0.498	0	1.3906	0.0619	0.6224	0.0323	0
1510		261.969	0.002	3.64123	0.00011	10.677	0.002	11.248	0.031	-2.378	0.785	-2.157	1.085	0	0.9369	0.0378	0.9995	0.0652	1
1519		321.691	0.000	5.87758	0.00005	11.040	0.001	11.284	0.001	7.817	-24.734	6.404	-25.987	0	3.6020	0.0316	3.5998	0.0270	24
2041		336.423	0.001	6.26336	0.00008	11.406	0.002	11.988	0.002	-7.360	3.873	-11.490	11.035	0	1.6066	0.0451	1.0423	0.0626	0
2041	AC	306.165	0.000	17.77356	0.00007	11.406	0.002	12.483	0.002	-7.360	3.873	-2.224	0.967	0	1.6066	0.0451	0.3213	0.0496	0
2048		350.367	0.001	5.37883	0.00005	11.418	0.001	11.860	0.002	2.243	1.434	-0.718	3.271	0	0.4947	0.0343	0.3272	0.0392	0
2049		194.268	0.000	5.36746	0.00003	12.837	0.001	13.801	0.002	-20.016	1.805	-4.545	2.961	0	2.7672	0.0329	0.7571	0.0217	0
2049	AC	270.560	0.000	9.50887	0.00003	12.837	0.001	14.180	0.002	-20.016	1.805	3.492	0.036	0	2.7672	0.0329	1.3860	0.0238	0
2050		333.661	0.001	6.99831	0.00007	11.102	0.002	12.935	0.003	-14.353	2.505	-13.194	2.982	1	3.7928	0.0354	3.8837	0.0620	7
2052		182.979	0.001	4.19698	0.00004	11.221	0.001	12.730	0.002	-19.444	7.481	-19.378	7.180	97	3.2664	0.0396	3.3253	0.0438	9
2052	AC	228.325	0.000	20.49247	0.00004	11.221	0.001	13.846	0.003	-19.444	7.481	-1.532	0.779	0	3.2664	0.0396	0.2852	0.0303	0
2053		33.078	0.000	4.91482	0.00003	12.214	0.001	13.054	0.001	3.548	-4.882	-2.069	-4.535	0	1.2152	0.0297	1.0855	0.0264	0
2056		24.053	0.001	3.56004	0.00005	12.945	0.002	12.749	0.002	-2.735	2.386	-3.046	2.517	4	1.5391	0.0351	1.5487	0.0359	4
2058		329.361	0.000	6.85339	0.00005	13.034	0.002	13.213	0.001	0.015	-0.754	0.236	-0.629	0	0.5069	0.0351	0.5664	0.0251	0
2479		274.046	0.000	5.94477	0.00005	13.033	0.001	13.191	0.002	-3.384	-6.614	-2.938	-0.285	0	1.6214	0.0374	0.3881	0.0276	0
2480		238.017	0.001	7.71328	0.00011	10.668	0.002	12.928	0.003	-5.692	0.203	-6.331	0.610	0	1.2923	0.0442	1.2901	0.0926	1
2480	AC	315.767	0.001	5.75591	0.00006	10.668	0.002	13.255	0.004	-5.692	0.203	1.269	-10.957	0	1.2923	0.0442	3.0337	0.0359	0
2481		255.864	0.000	5.36742	0.00005	12.305	0.002	13.599	0.002	-0.876	2.089	-1.328	1.253	0	0.5954	0.0385	0.5686	0.0246	0
2481	AC	72.125	0.000	10.74123	0.00005	12.305	0.002	13.633	0.001	-0.876	2.089	-3.271	1.580	0	0.5954	0.0385	0.2807	0.0242	0
2489		23.617	0.001	3.74778	0.00007	10.393	0.001	11.281	0.006	-4.785	0.167	-4.922	2.132	0	0.7582	0.0533	0.8806	0.0555	0
2490		189.588	0.001	5.88094	0.00005	11.422	0.010	12.051	0.002	-3.343	1.825	-0.065	2.106	0	0.3285	0.0505	0.7422	0.0380	0
2633		293.620	0.001	5.62429	0.00007	11.569	0.002	11.856	0.002	-4.844	2.752	6.498	-8.238	0	0.8925	0.0421	0.7566	0.0486	0
2635		289.828	0.000	8.82956	0.00006	10.495	0.001	12.387	0.002	-4.218	-0.470	-4.055	-0.461	5	1.1381	0.0524	1.1261	0.0417	1
2638		98.176	0.000	79.65792	0.00005	9.043	0.002	12.853	0.002	-6.138	-0.169	20.864	-12.585	0	1.5812	0.0462	25.8263	0.0337	0

Table 2 concludes on the next page.

Table 2 (conclusion): Gaia DR2 Cross-Match Results for Listed J Objects

J#	C	PA	e_PA	Sep	e_Sep	Vest1	e_Vest1	Vest2	e_Vest2	pmRA1	pmDE1	pmRA2	pmDE2	CPMS	Plx1	e_Plx1	Plx2	e_Plx2	PGRS
2639		268.845	0.000	49.70631	0.00004	10.683	0.001	13.094	0.003	-6.742	2.270	-6.178	3.335	1	1.0811	0.0348	2.4756	0.0308	0
2639	BC	65.596	0.000	5.83782	0.00003	13.094	0.003	13.302	0.003	-6.178	3.335	-5.845	2.639	0	2.4756	0.0308	2.6000	0.0201	0
2838		58.011	0.001	6.91249	0.00007	10.766	0.002	12.368	0.002	-0.662	-0.832	-2.847	0.570	0	0.7051	0.0593	0.6333	0.0420	0
2875		208.384	0.001	5.71969	0.00005	11.273	0.001	12.581	0.001	-3.980	-0.057	-16.947	-2.689	0	1.4208	0.0391	3.2662	0.0338	0
2876		153.196	0.001	5.24668	0.00008	11.205	0.001	11.899	0.003	-21.613	-1.566	-4.243	2.974	0	3.4896	0.0424	0.3979	0.0452	0
2876	AC	37.270	0.000	13.37154	0.00006	11.205	0.001	11.550	0.002	-21.613	-1.566	-20.818	-19.869	0	3.4896	0.0424	6.2456	0.0338	0
261		102.101	0.001	3.90096	0.00009	11.481	0.003	12.589	0.004	1.993	4.084	-0.845	-6.519	0	2.9185	0.0569	1.3040	0.0609	0
277		6.854	0.001	7.70996	0.00010	10.911	0.003	13.535	0.002	-2.933	-2.438	-4.341	-3.922	1	0.8999	0.0590	0.5614	0.0575	0
356		217.500	0.001	6.57617	0.00011	10.792	0.003	12.338	0.007	2.030	-3.308	-0.091	-0.108	0	0.8565	0.0819	0.4766	0.0812	0
664		194.880	0.001	3.40434	0.00006	12.686	0.002	13.254	0.004	6.456	-5.526	1.122	-4.969	0	1.8879	0.0449	1.3399	0.0330	0
1486		180.241	0.001	9.21598	0.00008	11.970	0.002	12.252	0.002	-2.284	-0.688	-17.916	-51.279	0	0.7393	0.0537	2.8149	0.0492	0
1974		53.657	0.001	3.92146	0.00005	13.150	0.002	14.205	0.003	-0.357	0.048	-0.574	0.391	0	0.8213	0.0244	0.7185	0.0296	0
1981		115.050	0.001	7.76494	0.00007	12.966	0.002	12.871	0.002	-1.151	-3.418	-1.347	-0.401	0	0.4325	0.0397	0.2790	0.0391	0
1982		238.915	0.001	4.90824	0.00005	14.120	0.005	14.189	0.002	-0.354	-1.833	-0.384	-1.499	0	0.3031	0.0254	0.2508	0.0269	0
2460		336.122	0.001	5.91347	0.00008	12.269	0.001	12.275	0.002	-1.644	4.394	-1.075	1.062	0	2.3518	0.0484	1.2476	0.0461	0
2485		127.485	0.000	6.55021	0.00004	12.717	0.002	13.630	0.002	-1.740	1.375	3.604	-10.424	0	0.1545	0.0361	1.3976	0.0229	0
2618		292.240	0.002	6.38459	0.00028	10.883	0.002	11.878	0.004	-4.303	-1.956	-3.700	-1.562	5	1.0333	0.2420	0.9108	0.0574	0
2632		72.116	0.000	33.81145	0.00006	9.641	0.002	12.627	0.002	-4.879	3.228	-1.007	-0.227	0	1.7447	0.0486	0.8064	0.0371	0
2751		126.517	0.001	5.70216	0.00006	12.528	0.002	13.664	0.003	3.675	-6.044	3.764	-6.168	39	1.0571	0.0414	1.0956	0.0261	1
2778		308.916	0.001	5.83739	0.00008	11.431	0.003	12.046	0.003	-10.264	27.785	-9.859	28.077	97	2.6479	0.0405	2.6627	0.0413	9
2811		163.302	0.000	7.48701	0.00005	11.864	0.002	13.564	0.002	-1.506	3.043	-0.747	-1.367	0	0.9646	0.0496	1.1279	0.0310	0
2824		95.458	0.001	5.26691	0.00006	11.761	0.002	12.979	0.002	3.913	-1.435	-1.300	-2.232	0	1.1100	0.0379	0.4102	0.0366	0
1522		10.240	0.001	8.88254	0.00009	10.979	0.003	11.887	0.002	-5.260	0.837	-5.093	0.619	4	0.9687	0.0720	0.9056	0.0534	1
1524		317.702	0.001	6.22694	0.00006	11.711	0.001	11.779	0.002	-3.337	1.890	-3.657	5.264	0	0.6377	0.0334	0.2823	0.0382	0
1524	AC	219.752	0.000	13.23908	0.00005	11.711	0.001	13.335	0.001	-3.337	1.890	-5.161	1.626	0	0.6377	0.0334	0.6151	0.0228	1
1526		355.768	0.000	7.43479	0.00004	11.779	0.001	12.208	0.001	-0.365	1.147	1.473	-11.099	0	0.7302	0.0305	1.3633	0.0303	0
1527		334.307	0.002	6.43792	0.00026	9.184	0.002	10.918	0.001	-5.483	26.665	-3.059	27.131	1	1.5718	0.0669	2.6627	0.2083	0
1529		131.510	0.001	8.43129	0.00008	11.685	0.001	12.106	0.001	-8.726	4.635	-8.435	5.193	1	1.4067	0.0862	1.2547	0.0283	0
1531		14.671	0.001	7.97205	0.00008	10.713	0.001	11.001	0.001	-9.476	4.842	-9.618	4.831	78	1.8788	0.0438	1.8672	0.0511	4
1532		196.795	0.000	10.12412	0.00007	11.873	0.002	12.454	0.001	-5.342	-2.956	-5.872	5.614	0	2.2060	0.0377	0.5450	0.0452	0
1541		290.444	0.000	7.06738	0.00006	10.998	0.001	12.175	0.002	-11.002	3.604	-12.106	2.974	0	1.6073	0.0464	1.6029	0.0407	3
2061		29.156	0.001	5.70365	0.00005	12.353	0.002	13.410	0.002	-7.643	7.778	-6.638	8.175	0	1.0595	0.0456	1.0370	0.0251	1
2645		306.128	0.000	7.01379	0.00006	11.446	0.002	11.853	0.002	-4.924	-0.045	-5.613	0.232	1	1.3754	0.0400	1.3676	0.0314	3

Jonckheere Double Star Photometry – Part XIV

(Continued from page 545)

pixel. V-filter. Located in Siding Spring, Australia. Elevation 1122m

- Astrometrica v4.10.0.427
- URAT1 and UCAC4 catalog
- MaxIm DL6 v6.08

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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 cosine

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

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

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

- 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

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

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.