Jonckheere Double Star Photometry – Part X: Hercules

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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 28 of the in total 82 Jonckheere objects in the constellation Hercules selected by a quick WDS data check for being potentially listed with questionable magnitudes. At least one image per object was taken with V-filter to allow for visual magnitude measurement by differential photometry. All objects were additionally checked for common proper motion and two qualify indeed as potential CPM pairs.

Introduction

As follow up to the report on J-objects I submitted so far I selected this time the J-objects in Hercules. To concentrate on the objects most in need of photometry I checked in the next step all objects for potentially suspect data – this process reduced the objects to check more in detail to 29. This does not mean that the data for the eliminated J-objects in Her are to be considered correct in all cases but the comparison of the given magnitudes with the UCAC4 fmag values suggests at least that any potential errors should be rather small.

Results of Photometry and Catalog Checking

For all but one of the selected J-objects one single image was taken with iTelescope iT24 with V-filter and 3s exposure time. The single image random effects seem less significant for the measured magnitudes as a magnitude error of ~0.1 or even a bit larger seems negligible in comparison with the Jonckheere objects often given magnitude errors in the range of up to 2 magnitudes. The images were then plate solved with Astrometrica using the URAT1 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. In one case, I had to take additional images with a different telescope to avoid issues with image quality.

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

- J# gives the number of the J-object
- RA/Dec gives the position in the HH:MM:SS/DD:MM:SS format for both components
- dRA and dDEc give the average plate solving error for RA and Dec in arcseconds
- Sep gives separation in arcseconds in the data lines calculated as

$$Sep = \sqrt{\left[\left(\cos\left(RA_1 - RA_2\right)\cos\left(Dec_1\right)\right)^2 + \left(Dec_2 - Dec_1\right)^2\right]}$$

  in radians
- ErrSep gives the calculated error range for Sep as

$$ErrSep = \sqrt{dRA^2 + dDec^2}$$

- PA gives position angle in degrees in the data lines calculated as

$$PA = \arctan\left[\frac{\left(RA_2 - RA_1\right)\cos\left(Dec_1\right)}{Dec_2 - Dec_1}\right]$$

  in radians depending on quadrant
- ErrPA = position angle error estimation in degrees

calculated as

$$ErrPA = \arctan\left(\frac{ErrSep}{Sep}\right)$$

assuming the worst case that *ErrSep* points perpendicular to the separation vector

- Mag gives Vmag for both components according to plate solving
- Err_Mag = magnitude error estimation calculated as

$$ErrMag = \sqrt{dVmag^2 + \left[2.5\log\left(1+1/SNR\right)\right]^2}$$

- SNR as signal to noise ratio for the given object
- dVmag as average magnitude plate solving error
- Date gives the Julian observation epoch (instead of the Bessel epoch used up to 2017 in the WDS catalog)
- N gives the number of images used
- Notes indicate the telescope used, number of images with exposure time, and additional comments if considered necessary.

In an additional step, I checked all objects for common proper motion using the UCAC5 catalog data when available. Table 2 lists the found data for the J objects in question and the assessment if the proper motion data allows for common proper motion using the following structure:

First row:

- J# gives the number of the J-object
- RA/Dec gives the GAIA DR1 position as given in the UCAC5 catalog in degrees for the primary
- Sep gives separation in arcseconds in the data lines calculated as

$$Sep = \sqrt{\left[\left(\cos\left(RA_1 - RA_2\right)\cos\left(Dec_1\right)\right)^2 + \left(Dec_2 - Dec_1\right)^2\right]}$$

in radians

- PA gives position angle in degrees in the data lines calculated as

$$PA = \arctan\left[\frac{\left(RA_2 - RA_1\right)\cos\left(Dec_1\right)}{Dec_2 - Dec_1}\right]$$

in radians depending on quadrant

- M1(G) and M2(G) give the GAIA DR1 Gmag values for both components as given in the UCAC5 catalog
- pmRA1, pmDec1/pmRA2, pmDec2 give the UCAC5 proper motion data and e_pm1/2 gives the total pm data error for both components
- Ap gives the GAIA aperture diameter (calculated for a corresponding surface with the used rectangular aperture)
- Me gives the observation method
- Date gives the GAIA DR1 observation epoch
- CPM Rat gives the CPM rating according to Knapp and Nanson 2017 (see Appendix A)
- Source/Notes gives the reference to the used catalog and additional comments on the objects

Second row:

- RA/Dec gives the UCAC5 position in degrees for the primary (from UCAC images re-reduced with TGAS reference stars)
- Sep gives separation in arcseconds in the data lines calculated as

$$Sep = \sqrt{\left[\left(\cos\left(RA_1 - RA_2\right)\cos\left(Dec_1\right)\right)^2 + \left(Dec_2 - Dec_1\right)^2\right]}$$

in radians

- PA gives position angle in degrees in the data lines calculated as before.
- Ap gives the used UCAC5 aperture
- Me gives the observation method
- Date gives the UCAC5 observation epoch (average from the used images)
- Source/Notes gives UCAC5 as used catalog and additional comments on the objects if necessary.

Summary

A good part of the listed J-objects in Hercules shows the expected significant magnitude difference compared with the WDS catalog data. Further, only two of these objects qualify as solid or at least good CPM candidates based on a rating scheme using UCAC5 proper motion data with the caveat that several objects are with at least one component not covered by UCAC5.

(Text continues on page 352)

Table 1: Measurement results for J objects in Her

J#		RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
98	A	18:33:12.263	17:28:33.74	0.08	0.07	3.928	0.106	146.883	1.550	10.324	0.110	173.98	0.11	2017.467	1	iT24 1x3s. Touching star disks
	B	18:33:12.413	17:28:30.45							11.894	0.111	73.55				
103	A	18:42:23.866	14:03:15.31	0.09	0.09	5.718	0.127	164.502	1.275	8.959	0.110	303.21	0.11	2017.467	1	iT24 1x3s. Touching star disks
	B	18:42:23.971	14:03:09.80							12.166	0.112	47.72				
399	A	16:23:11.312	23:41:16.97	0.06	0.07	4.931	0.092	49.997	1.071	10.168	0.080	204.53	0.08	2017.467	1	iT24 1x3s
	B	16:23:11.587	23:41:20.14							12.514	0.082	58.90				
400	A	16:44:06.847	42:02:39.67	0.06	0.06	5.945	0.085	173.761	0.818	12.075	0.071	88.49	0.07	2017.467	1	iT24 1x3s. SNR B <20
	B	16:44:06.905	42:02:33.76							14.889	0.102	14.27				
469	A	18:50:24.772	12:43:33.61	0.08	0.09	2.773	0.120	110.920	2.487	11.812	0.081	81.47	0.08	2017.467	1	iT24 1x3s. Touching star disks
	B	18:50:24.949	12:43:32.62							12.796	0.086	33.47				
532	A	18:54:51.539	12:59:59.89	0.09	0.10	4.420	0.135	3.792	1.744	11.056	0.081	113.60	0.08	2017.467	1	iT24 1x3s
	B	18:54:51.559	13:00:04.30							12.658	0.084	41.71				
738	A	16:41:30.635	21:47:29.57	0.07	0.09	1.969	0.114	247.924	3.314	11.813	0.095	36.11	0.09	2017.467	1	iT24 1x3s.Overlapping star disks
	B	16:41:30.504	21:47:28.83							11.724	0.094	37.91				
740	A	17:03:14.600	34:58:55.70	0.07	0.07	2.826	0.099	224.088	2.006	10.239	0.080	196.82	0.08	2017.467	1	iT24 1x3s. Touching star disks
	B	17:03:14.440	34:58:53.67							10.926	0.080	124.08				
752	A	18:25:07.654	16:47:44.25	0.11	0.11	4.630	0.156	256.128	1.924	10.863	0.091	78.65	0.09	2017.467	1	iT24 1x3s
	B	18:25:07.341	16:47:43.14							12.035	0.095	34.06				
757	A	18:02:15.397	38:04:10.50	0.12	0.11	3.170	0.163	327.050	2.940	11.879	0.073	52.78	0.07	2017.467	1	iT24 1x3s. Touching star disks
	B	18:02:15.251	38:04:13.16							12.456	0.035	30.55				
799	A	18:36:59.774	19:10:17.73	0.12	0.10	2.641	0.156	77.535	3.385	11.488	0.081	72.69	0.08	2017.467	1	iT24 1x3s. Touching star disks
	B	18:36:59.956	19:10:18.30							11.882	0.082	55.19				
1032	A	17:26:48.230	22:37:43.12	0.10	0.10	4.119	0.141	350.324	1.967	11.253	0.111	64.38	0.11	2017.467	1	iT24 1x3s. Touching star disks
	B	17:26:48.180	22:37:47.18							11.568	0.112	47.32				
1033	A	17:26:59.379	22:43:42.44	0.10	0.10	6.312	0.141	247.654	1.283	10.791	0.090	116.61	0.09	2017.467	1	iT24 1x3s
	B	17:26:58.957	22:43:40.04							12.212	0.093	50.16				
1071	A	18:42:20.344	14:06:36.03	0.09	0.09	5.089	0.127	66.983	1.433	13.118	0.110	303.21	0.11	2017.467	1	iT24 1x3s. Same image as J103
	B	18:42:20.666	14:06:38.02							13.843	0.112	47.72				
1127	A	18:00:36.903	30:13:24.59	0.08	0.11	2.862	0.136	341.244	2.721	12.544	0.073	55.38	0.07	2017.467	1	iT24 1x3s. Touching star disks
	B	18:00:36.832	30:13:27.30							12.729	0.074	43.12				
1132	A	18:06:37.776	20:14:20.98	0.10	0.11	3.275	0.149	134.849	2.599	12.021	0.121	63.42	0.12	2017.467	1	iT24 1x3s. Touching star disks
	B	18:06:37.941	20:14:18.67							12.719	0.125	32.02				

Table 1 continues on next page.

Table 1 (continues). Measurement results for J objects in Her

J#		RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
1133	A	18:32:06.920	13:59:16.35	0.11	0.10	2.237	0.149	124.280	3.802	12.257	0.092	55.03	0.09	2017.467	1	iT24 1x3s. Touching/ overlapping star disks. The WDS listed epoch 2000 measurement of this double with 0.55" separation has to be in error
	B	18:32:07.047	13:59:15.09							12.887	0.095	35.41				
1170	A	18:34:02.651	12:20:16.56	0.11	0.11	4.546	0.156	120.247	1.960	11.127	0.101	89.50	0.10	2017.467	1	iT24 1x3s
	B	18:34:02.919	12:20:14.27							13.044	0.108	26.30				
1197	A	18:33:50.895	12:21:15.88	0.09	0.10	2.290	0.135	180.367	3.362	13.515	0.136	27.59	0.13	2017.467	1	iT24 1x3s. Touching/ overlapping star disks
	B	18:33:50.894	12:21:13.59							13.329	0.134	35.04				
1218	A	18:05:03.407	38:29:55.26	0.06	0.05	2.969	0.078	166.743	1.507	12.171	0.081	19.39	0.06	2017.578	10	iT18 10x3s. SNR B<10
	B	18:05:03.465	38:29:52.37							13.628	0.137	8.29				
	A	18:05:03.407	38:29:55.25	0.06	0.07	3.062	0.092	166.701	1.725	12.187	0.051	122.96	0.05	2017.691	5	iT24 5x6s. Touching star disks
	B	18:05:03.467	38:29:52.27							13.636	0.054	56.25				
1278	A	18:56:30.080	15:56:10.46	0.11	0.12	2.284	0.163	97.547	4.076	11.778	0.101	62.88	0.10	2017.467	1	iT24 1x3s. Touching/ overlapping star disks
	B	18:56:30.237	15:56:10.16							12.356	0.104	36.34				
2098	A	17:56:40.229	15:41:09.93	0.12	0.11	4.292	0.163	130.197	2.172	12.779	0.114	37.31	0.11	2017.467	1	iT24 1x3s
	B	17:56:40.456	15:41:07.16							12.952	0.114	33.74				
2124	A	18:15:19.617	20:11:56.77	0.10	0.11	3.861	0.149	348.220	2.205	11.664	0.151	78.23	0.15	2017.467	1	iT24 1x3s
	B	18:15:19.561	20:12:00.55							13.242	0.157	22.50				
2912	A	18:29:17.376	17:41:51.70	0.11	0.11	6.771	0.156	143.175	1.316	11.231	0.160	93.25	0.16	2017.467	1	iT24 1x3s
	B	18:29:17.660	17:41:46.28							13.976	0.167	22.32				
2913	A	18:29:23.427	21:43:16.72	0.10	0.11	2.515	0.149	113.923	3.382	12.128	0.122	49.94	0.12	2017.467	1	iT24 1x3s. Touching/ overlapping star disks
	B	18:29:23.592	21:43:15.70							12.640	0.123	36.73				

Table 1 concludes on next page.

Table 1 (conclusionn). Measurement results for J objects in Her

J#		RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
2924	A	18:46:04.863	18:15:40.16	0.11	0.12	3.637	0.163	69.395	2.563	12.179	0.113	40.95	0.11	2017.467	1	iT24 1x3s. Touching star disks
	B	18:46:05.102	18:15:41.44							12.623	0.117	26.95				
2931	A	18:55:17.751	18:16:07.11	0.12	0.11	5.257	0.163	143.024	1.774	13.154	0.115	30.35	0.11	2017.467	1	iT24 1x3s. Touching star disks. Curious mag difference compared with WDS suggests object mismatch
	B	18:55:17.973	18:16:02.91							11.849	0.111	59.49				
3268	A	17:58:22.742	18:14:13.52	0.11	0.10	3.970	0.149	215.547	2.145	13.338	0.116	29.51	0.11	2017.467	1	iT24 1x3s
	B	17:58:22.580	18:14:10.29							13.779	0.117	26.92				
3324	A	16:29:51.725	24:52:37.50	0.11	0.08	2.224	0.136	60.349	3.500	11.899	0.091	85.20	0.09	2017.467	1	iT24 1x3s. Touching/ overlapping star disks
	B	16:29:51.867	24:52:38.60							12.672	0.094	42.28				

Explanations regarding the content of the Notes column:

"Touching star disks" indicates that the rims of the star disks are touching and that the measurement results might be a bit less precise than with clearly separated star disks

"Touching/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

"SNR <20" indicates that the measurement result 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

"SNR <10" indicates that the measurement result is probably a bit less precise than desired due to a very low SNR value but this is already included in the calculation of the magnitude error range estimation

"Image quality questionable" or similar indicates rather large average errors for the reference stars used for plate solving for different reasons (mostly atmospheric influences). But this is at least to some degree already included in the calculation of the error range estimation

Table 2. J objects in Her being checked for being potentially CPM pairs

J#	RA	Dec	Sep "	PA °	M1(G)	M2(G)	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
98	278.30109970	17.4760136	4.00	146.8	10.25	11.65	-1.80	-7.40	1.70	-3.60	-7.10	3.39	0.96	Hg	2015.000	CACB	GAIA DR1. PM data from UCAC5 catalog. Rather optical
	278.30110670	17.4760411	4.02	146.5									0.20	Eu	2001.575		UCAC5
103	280.59944330	14.0542281	5.71	164.5	8.80	11.68	1.80	-13.70	2.40	-1.10	-14.80	8.49	0.96	Hg	2015.000	CBCB	GAIA DR1. PM data from UCAC5 catalog. Rather optical
	280.59943640	14.0542794	5.71	164.1									0.20	Eu	2001.486		UCAC5
399	245.79716030	23.6880494	4.99	49.8	9.77	12.31	-11.80	-4.70	1.70	-14.30	-3.20	2.83	0.96	Hg	2015.000	CCCB	GAIA DR1. PM data from UCAC5 catalog. Obviously optical
	245.79720850	23.6880669	5.00	50.2									0.20	Eu	2001.530		UCAC5
400	251.02855940	42.0443631	5.88	175.8	11.82	14.39	-17.80	-10.10	1.98	10.70	-11.40	4.10	0.96	Hg	2015.000	CCCB	GAIA DR1. PM data from UCAC5 catalog. Obviously optical
	251.02864310	42.0443983	5.85	179.3									0.20	Eu	2002.480		UCAC5
469	282.60319190	12.7260114	3.04	109.3	11.70	13.01	-2.30	-8.70	2.12	-0.40	-24.40	7.50	0.96	Hg	2015.000	CCCB	GAIA DR1. PM data from UCAC5 catalog. Obviously optical
	282.60320080	12.7260442	2.96	105.5									0.20	Eu	2001.455		UCAC5
532	283.71471690	12.9999708	4.52	5.9	10.83	12.40	-3.00	-0.20	1.41	-4.60	-1.10	1.63	0.96	Hg	2015.000	CCCC	GAIA DR1. PM data from UCAC5 catalog. Obviously optical
	283.71472860	12.9999717	4.54	6.2									0.20	Eu	2001.463		UCAC5
738	250.37771581	21.7915261	2.17	247.5	11.70	11.58							0.96	Hg	2015.000		GAIA DR1. No UCAC5 (nor 2MASS or URAT1) objects for B available
740	255.81079420	34.9821197	2.82	226.2	10.08	10.94	9.70	23.40	1.70	-4.50	5.20	2.97	0.96	Hg	2015.000	CCCB	GAIA DR1. PM data from UCAC5 catalog. Obviously optical
	255.81075270	34.9820375	2.53	227.2									0.20	Eu	2002.355		UCAC5
752	276.28188140	16.7956228	4.63	258.3	10.36	11.81	12.70	9.30	1.70	-2.90	-8.90	3.39	0.96	Hg	2015.000	CCCB	GAIA DR1. PM data from UCAC5 catalog. Opposite pm direction, obviously optical
	276.28183190	16.7955881	4.38	260.9									0.20	Eu	2001.565		UCAC5
757	270.56413610	38.0696086	3.47	323.2	11.60	12.67	5.70	2.60	1.84	6.10	6.40	2.83	0.96	Hg	2015.000	CCCB	GAIA DR1. PM data from UCAC5 catalog. Obviously optical
	270.56411140	38.0695997	3.43	322.7									0.20	Eu	2002.605		UCAC5
799	279.24927280	19.1715997	2.70	71.9	11.06	12.45	-3.30	-4.20	1.56	4.80	0.80	3.68	0.96	Hg	2015.000	CBCB	GAIA DR1. PM data from UCAC5 catalog. Obviously optical
	279.24928580	19.1716153	2.57	72.5									0.20	Eu	2001.604		UCAC5
1032	261.7009142	22.6286114	4.05	350.3	11.08	11.38	-18.00	23.00	1.56	-17.50	23.90	1.84	0.96	Hg	2015.000	AABB	GAIA DR1. PM data from UCAC5 catalog. Solid CPM candidate
	261.70098690	22.6285261	4.04	350.2									0.20	Eu	2001.619		UCAC5
1033	261.74743440	22.7284850	6.52	246.8	10.05	11.83	-3.80	-12.90	1.56	-12.90	-15.90	3.39	0.96	Hg	2015.000	CCCB	GAIA DR1. PM data from UCAC5 catalog. Obviously optical
	261.74744980	22.7285331	6.40	246.8									0.20	Eu	2001.618		UCAC5

Table 2 continues on next page.

Table 2 (continued). J objects in Her being checked for being potentially CPM pairs

J#	RA	Dec	Sep "	PA °	M1(G)	M2(G)	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
1071	280.58475810	14.1100147	5.14	67.6	12.80	13.01	-0.80	-10.00	1.70	-1.80	-2.50	1.84	0.96	Hg	2015.000	CCCB	GAIA DR1. PM data from UCAC5 catalog. Obviously optical
	280.58476110	14.1100522	5.12	68.7									0.20	Eu	2001.484		UCAC5
1127	270.15380810	30.2234269	2.93	337.3	12.48	12.77	38.70	-95.00	1.98	11.40	-38.20	2.69	0.96	Hg	2015.000	CCBA	GAIA DR1. PM data from UCAC5 catalog. Very different pm speed, obviously optical
	270.15365080	30.2237606	2.14	338.4									0.20	Eu	2002.357		UCAC5
1132	271.65743330	20.2390786	3.26	139.6	11.90	12.64	-17.10	-5.00	1.70	-17.50	-6.20	1.84	0.96	Hg	2015.000	BABB	GAIA DR1. PM data from UCAC5 catalog. Potential CPM candidate
	271.65750110	20.2390969	3.25	139.3									0.20	Eu	2001.606		UCAC5
1133	278.02883920	13.9877994	2.24	124.2	12.19	12.87	-6.60	-4.00	1.56	-6.00	-5.70	1.84	0.96	Hg	2015.000	CBCB	GAIA DR1. PM data from UCAC5 catalog. Rather optical
	278.02886440	13.9878144	2.22	123.8									0.20	Eu	2001.483		UCAC5
1170	278.51097720	12.3379464	4.73	118.4	10.37	12.50	-1.70	-0.70	1.70	4.20	14.00	2.12	0.96	Hg	2015.000	CCCB	GAIA DR1. PM data from UCAC5 catalog. Obviously optical
	278.51098390	12.3379492	4.76	121.0									0.20	Eu	2001.449		UCAC5
1197																	No UCAC5/GAIA DR1 objects available
1218	271.26417785	38.4986744	3.00	164.2	11.93	13.32							0.96	Hg	2015.000		GAIA DR1. M1 and M2 are G-band. No UCAC5 (nor 2MASS or URAT1) objects for B available
1278																	No UCAC5/GAIA DR1 objects available
2098	269.16760780	15.6860886	4.17	130.1	12.40	12.38	1.00	-6.60	1.56	3.60	-11.10	1.56	0.96	Hg	2015.000	CCCB	GAIA DR1. PM data from UCAC5 catalog. Obviously optical
	269.16760390	15.6861133	4.10	129.7									0.20	Eu	2001.508		UCAC5
2124	273.83176330	20.1990036	3.96	346.5	11.10	13.19	-6.60	10.30	1.56	-6.50	9.70	5.37	0.96	Hg	2015.000	AACB	GAIA DR1. PM data from UCAC5 catalog. Good CPM candidate with the caveat of a rather large pm error for B
	273.83178930	20.1989656	3.96	346.5									0.20	Eu	2001.615		UCAC5
2912	277.32242610	17.6976403	6.34	142.2	10.59	13.43	0.50	-2.80	1.56	-3.20	-3.10	2.12	0.96	Hg	2015.000	CCCC	GAIA DR1. PM data from UCAC5 catalog. Obviously optical
	277.32242420	17.6976508	6.36	141.8									0.20	Eu	2001.579		UCAC5
2913	277.34753640	21.7212992	3.14	117.5	11.58	12.66	-0.50	-12.00	1.56	1.40	-11.80	1.56	0.96	Hg	2015.000	CACB	GAIA DR1. PM data from UCAC5 catalog. Rather optical
	277.34753840	21.7213436	3.12	117.8									0.20	Eu	2001.639		UCAC5

Table 2 concludes on next page.

Table 2 (conclusion). J objects in Her being checked for being potentially CPM pairs

J#	RA	Dec	Sep "	PA °	M1(G)	M2(G)	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
2924	281.52035250	18.2609917	3.71	66.1	11.79	12.29	0.60	-1.20	1.63	21.40	-46.70	1.70	0.96	Hg	2015.000	ACCB	GAIA DR1. PM data from UCAC5 catalog. Obviously optical. Fast proper motion of B changes Sep and PA over time noticeable
	281.52035030	18.2609961	3.77	55.8									0.20	Eu	2001.583		UCAC5
2931	283.82393060	18.2686453	5.60	143.3	12.46	11.63	-3.60	-20.10	1.70	-5.60	-58.90	1.56	0.96	Hg	2015.000	CCBB	GAIA DR1. PM data from UCAC5 catalog. Obviously optical
	283.82394470	18.2687203	5.21	139.6									0.20	Eu	2001.583		UCAC5
3268	269.59482000	18.2370367	3.98	219.5	12.95	13.33	-4.50	-3.60	1.70	-5.60	-2.40	1.84	0.96	Hg	2015.000	CBCB	GAIA DR1. PM data from UCAC5 catalog. Rather optical
	269.59483750	18.2370503	3.98	219.1									0.20	Eu	2001.586		UCAC5
3324	247.46542810	24.8770486	2.61	55.2	11.76	12.68	-11.60	14.60	1.56	-10.30	19.00	1.84	0.96	Hg	2015.000	CCBB	GAIA DR1. PM data from UCAC5 catalog. Rather optical
	247.46547580	24.8769942	2.57	56.1									0.20	Eu	2001.557		UCAC5

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References

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Knapp, Wilfried; Nanson, John – 2017, A new concept for counter-checking of assumed CPM pairs, Journal of Double Star Observing, Vol. 13 No 1 pp. 31-51

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iT18: 318mm CDK with 2541mm focal length. CCD: SBIG-STXL-6303E. Resolution 0.73 arcsec/pixel. V-filter. No transformation coefficients available. Located in Nerpio, Spain. Elevation 1650m
GAIA DR1 catalog
MaxIm DL6 v6.08
POSS images
SDSS DR9 and DR7 catalogs
SDSS images
SIMBAD
UCAC4 catalog
UCAC5 catalog
URAT1 catalog
VizieR
Washington Double Star Catalog

Appendix A

CPM rating scheme according to Knapp/Nanson 2017 with extensions:

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 relationship separation to average proper motion speed:

- Proper motion vector direction rating: “A” for within the error range identical direction, “B” for similar direction within the double error range and “C” for outside
- Proper motion vector length rating: “A” for within the error range identical length, “B” for similar length within the double error range and C for outside
- Error size rating: “A” for error size of less than 5% of the proper motion vector length, “B” for less than 10% and “C” for a larger error size
- Rating for relation separation to average proper motion speed: “A” for less than 100 years, “B” for 100 to 1000 years and “C” for above.

To compensate for (depending on the selected objects and available catalogs) excessively large position errors resulting an “A” rating despite rather high deviations absolute upper limits are applied regardless calculated error size:

- Proper motion vector direction: Max. 2.86° difference for an “A” and 5.72° for a “B”
- Proper motion vector length: Max. 5% difference for an “A” and 10% for a “B”

Modification for cases of very small position errors (when for example using SDSS9 instead of 2MASS or directly proper motion data from GAIA DR1 or UCAC5) with the consequence that the requirements to get an A or even B CPM rating get unreasonable hard:

- The from the position error resulting error estimation for proper motion vector direction and length is in this case calculated as root mean square from both position errors (instead of so far only the larger 2MASS one)
- If the PM vector direction difference is larger than this calculated “allowed” error but still less than 0.5° then an “A” is given, a “B” is given for larger than 0.5 but less than 1 degree, and a “C” is given if above
- If the PM vector length difference is larger than this calculated “allowed” error but still less than 0.5% then an “A” is given, a “B” is given for larger than 0.5 but less than 1 percent, and a “C” is given if above.