Jonckheere Double Star Photometry – Part V: Cancer

Wilfried R.A. Knapp

Vienna, Austria

wilfried.knapp@gmail.com

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 have magnitudes which are obviously far too bright. This report covers the Jonckheere objects in the constellation Cancer. Only one image per object was taken as despite the risk of random effects even a single measurement is better than the currently usually given estimation, although the J-objects in this constellation seem with some exceptions better covered with observations as usual for Jonckheere doubles.

Introduction

The degree of contamination of the WDS catalog with wrong magnitude data is rather high – this might very well be a side effect of magnitudes considered being not as important as the basic double star parameters separation and position angle. Measurements of magnitudes without these basic parameters are not even counted as observations in the WDS catalog. As follow up to the report on J-objects so far, I selected this time all J-objects in Cancer to be imaged for measurements with a remote telescope located in Spain. To counter the single image random effects especially for the astrometry results, I checked catalogs like SDSS, URAT1 and GAIA DR1 with recent position data. 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 magnitude errors in the range of up to 2 magnitudes for Jonckheere objects.

Results of photometry and catalog checking

For each of the selected J-objects, one single image was taken with iTelescope iT18 with V-filter and 3s exposure time and plate solved with Astrometrica, using the URAT1 catalog with reference stars in the Vmag range of 8.5 to 14.5 and 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. As the companion of one double star was too faint to be resolved in the iT18 image, I took for this object additional images with iT24 for a stack.

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

- The header line gives the WDS catalog data for each object per 08/2016 with RA/Dec in the HH:MM:SS/DD:MM:SS format with Date giving the year of the last observation
- The following rows give the data for the object in existing catalogs as far as available with
    - ◊ RA/Dec in decimal degrees with the catalog reference given in the Source/Notes column
    - ◊ Estimated visual M1 and M2 for 2MASS objects calculated from J- and K-band magnitudes if available
    - ◊ Visual M1 and M2 for URAT1 objects if available
    - ◊ Used Aperture and observation method code is given in the Ap and Me columns. As GAIA uses a rectangular aperture the value given in the Ap column is the calculated diameter for a corresponding circular surface
    - ◊ Date gives the Bessel observation epoch

- ◊ If 2MASS (or in some cases SDSS9) and GAIA DR1 positions are available then also proper motion data is calculated (using the formulas provided by Buchheim – 2008 to determine proper motion vector direction and proper motion vector length) and checked for potential common proper motion with the CPM rating procedure according to Knapp and Nanson 2016
- The last row gives then the measurements based on the iT18 images
  - ◊ RA/Dec in decimal degrees from plate solving
  - ◊ Sep gives separation in arcseconds in the data lines calculated as SQRT(((RA2-RA1) *cos(Dec1))^2+(Dec2-Dec1)^2) in radians
  - ◊ PA gives position angle in degrees in the data lines calculated as arctan((RA2-RA1) *cos(Dec1))/(Dec2-Dec1)) in radians depending on quadrant
  - ◊ Visual magnitudes M1 and M2 based on the plate solving results
  - ◊ Measurement error estimations calculated on base of the average plate solving errors are given in a separate table in the appendix.

Summary

Table 1 shows with few exceptions significant differences for the magnitudes compared with the WDS data even if the J-objects in Cancer seem rather well researched in comparison with other northern constellations. A small part of the objects qualify as CPM pairs based on calculations with the now available GAIA DR1 data.

Acknowledgements

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

- 2MASS catalog
- 2MASS images
- AAVSO APASS
- AAVSO VPhot
- Aladin Sky Atlas v9.0
- Astrometrica v4.10.0.427
- AstroPlanner v2.2
- iTelescope:
- iT18: 318mm CDK with 2541mm focal length. CCD: SBIG-STXL-6303E. Resolution 0.73 arcsec/pixel. V-filter. Located in Nerpio, Spain. Elevation 1650m
- iT24: 610mm CDK with 3962mm focal length. Resolution 0.625 arcsec/pixel. V-filter. No transformation coefficients available. Located in Auberry, California. Elevation 1405m
- GAIA DR1 catalog
- MaxIm DL6 v6.08
- POSS images
- SDSS DR9 and DR7 catalogs
- SDSS images
- SIMBAD
- UCAC4 catalog
- URAT1 catalog
- VizieR
- Washington Double Star Catalog

References

Buchheim, Robert, 2008, "CCD Double-Star Measurements at Altimira Observatory in 2007", *Journal of Double Star Observations*, **4**, 27-31.

Knapp, Wilfried; Nanson, John, 2016, "A New Concept for Counter-Checking of Assumed CPM Pairs", *JDSO*, **12**, 31-51.

Jonckheere Double Star Photometry – Part V: Cancer

Table 1. J objects in Cancer

J#	RA	Dec	Sep "	PA °	M1	M2	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
46	07:55:39.13	+12:40:08.4	2.5	287.0	9.90	10.70	0	-15							2002		WDS07557+1240 values per 08/2016
	118.91308497	12.6690270	2.57	285.8									0.96	Hg	2015		GAIA DR1
	118.91306250	12.6690306	2.31	280.5	10.43	11.15							0.31	C	2016.088		iT18 1x3s/URAT1. Overlapping star disks, image quality not very good
																	Despite the clear elongation in the 2MASS images there is no 2MASS catalog object for B, the same goes for URAT1
J#	**RA**	**Dec**	**Sep"**	**PA°**	**M1**	**M2**	**pmRA1**	**pmDec1**	**e_pm1**	**pmRA2**	**pmDec2**	**e_pm2**	**Ap**	**Me**	**Date**	**CPM Rat**	**Source/Notes**
73	08:25:57.62	+07:49:08.6	4.1	217.0	8.75	12.00	-20	6							2000		WDS08260+0749 values per 08/2016
	126.49006100	7.8190020	3.90	216.9	8.78	8.84							1.30	E2	2000.181		2MASS. M1 and M2 estimated from J- and K-band
	126.48997611	7.8190449	4.07	217.6			-20.43	10.41	14.80	-30.02	3.34	11.94	0.96	Hg	2015	CCCB	GAIA DR1. PM data calculated from position comparison with 2MASS - obviously no CPM
	126.48993333	7.8190278	3.80	216.8	8.68	10.69							0.31	C	2016.090		iT18 1x3s/URAT1
J#	**RA**	**Dec**	**Sep"**	**PA°**	**M1**	**M2**	**pmRA1**	**pmDec1**	**e_pm1**	**pmRA2**	**pmDec2**	**e_pm2**	**Ap**	**Me**	**Date**	**CPM Rat**	**Source/Notes**
76	09:00:18.96	+09:17:18.2	4.4	263.0	10.98	13.40	-44	-12		-52	-16				2000		WDS09003+0917 values per 08/2016
	135.07899500	9.2884050	4.40	262.7	10.79	12.28							1.30	E2	2000.478		2MASS. M1 and M2 estimated from J- and K-band
	135.07872056	9.2883553	4.39	262.8			-65.51	-12.01	6.19	-67.83	-11.78	6.51	0.96	Hg	2015	AABA	GAIA DR1. PM data calculated from position comparison with 2MASS - solid CPM candidate
	135.07872500	9.2883472	4.44	263.5	10.92	12.46							0.31	C	2016.088		iT18 1x3s. SNR B<20
J#	**RA**	**Dec**	**Sep"**	**PA°**	**M1**	**M2**	**pmRA1**	**pmDec1**	**e_pm1**	**pmRA2**	**pmDec2**	**e_pm2**	**Ap**	**Me**	**Date**	**CPM Rat**	**Source/Notes**
77	09:05:04.69	+10:29:23.3	0.9	136.0	9.92	10.22	-21	-22		-21	-22				2013		WDS09051+1029 values per 08/2016
	136.26948333	10.4896861			9.32								0.31	C	2016.254		iT18 1x3s. No resolution. Combined magnitude confirms current WDS mag values 9.92 and 10.22 but as Vmags (WDS code "B" in error?)
																	No resolution in any available image, not even an elongation. WDS PM values suggest CPM - but POSS I to II images do not show significant proper motion

Table 1 continues on next page.

Jonckheere Double Star Photometry – Part V: Cancer

Table 1 (continued). J objects in Cancer

J#	RA	Dec	Sep"	PA°	M1	M2	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
375 AB	08:08:54.70	+12:12:29.5	9.7	154.0	11.30	11.30	-16	-14		-9	-69				2014		WDS08089+1213 values per 08/2016
	122.22817200	12.2076710	8.96	152.3	11.46	11.91							1.30	E2	2000.908		2MASS. M1 and M2 estimated from J- and K-band
	122.22811916	12.2076252	9.62	153.7			-13.19	-11.71	6.54	-6.18	-61.35	6.54	0.96	Hg	2015	CCCB	GAIA DR1. PM data calculat-ed from position comparison with 2MASS - obviously no CPM
	122.22812083	12.2076139	9.60	153.6	11.52	11.80							0.31	C	2016.088		iT18 1x3s
J#	**RA**	**Dec**	**Sep"**	**PA°**	**M1**	**M2**	**pmRA1**	**pmDec1**	**e_pm1**	**pmRA2**	**pmDec2**	**e_pm2**	**Ap**	**Me**	**Date**	**CPM Rat**	**Source/Notes**
375 AC	08:08:54.70	+12:12:29.5	14.9	352.0	11.01	13.26	-16	-14		1	7				2014		WDS08089+1213 values per 08/2016
	122.22817200	12.2076710	14.64	350.9	11.46	12.97							1.30	E2	2000.908		2MASS. M1 and M2 estimated from J- and K-band
	122.22811916	12.2076252	14.79	352.0			-13.19	-11.71	6.54	4.57	1.55	6.54	0.96	Hg	2015	CCCC	GAIA DR1. PM data calculat-ed from position comparison with 2MASS - obviously no CPM
	122.22812083	12.2076139	14.95	352.0	11.52	12.99							0.31	C	2016.088		iT18 1x3s
J#	**RA**	**Dec**	**Sep"**	**PA°**	**M1**	**M2**	**pmRA1**	**pmDec1**	**e_pm1**	**pmRA2**	**pmDec2**	**e_pm2**	**Ap**	**Me**	**Date**	**CPM Rat**	**Source/Notes**
376	08:09:16.48	+12:03:31.4	2.1	284.0	9.20	9.60	6	-4							2008		WDS08092+1202 values per 08/2016
	122.31867800	12.0587710	2.19	280.2		16.05							2.50	Es	2005.189		SDSS DR9. Vmags estimated from (gmag+rmag)/2
	122.31866267	12.0587168	2.15	283.8			-5.50	-19.88	6.42	0.86	-7.35	6.42	0.96	Hg	2015	CCCB	GAIA DR1. PM data calculated from position comparison with SDSS DR9 - obviously no CPM
	122.31865417	12.0587417	1.99	279.0	11.20	11.69							0.31	C	2016.088		iT18 1x3s. Touching star disks
J#	**RA**	**Dec**	**Sep"**	**PA°**	**M1**	**M2**	**pmRA1**	**pmDec1**	**e_pm1**	**pmRA2**	**pmDec2**	**e_pm2**	**Ap**	**Me**	**Date**	**CPM Rat**	**Source/Notes**
377	08:14:10.49	+06:59:43.1	1.8	355.0	12.20	12.90									2012		WDS08142+0658 values per 08/2016
	123.54369200	6.9952380	1.76	356.6									2.50	Es	2003.076		SDSS DR9
	123.54372083	6.9952139	1.69	350.4	11.88	13.53							0.31	C	2016.088		iT18 1x3s. Overlapping star disks
																	No objects for B in 2MASS, URAT1 and GAIA DR1. No SDSS9 object for A and B
J#	**RA**	**Dec**	**Sep"**	**PA°**	**M1**	**M2**	**pmRA1**	**pmDec1**	**e_pm1**	**pmRA2**	**pmDec2**	**e_pm2**	**Ap**	**Me**	**Date**	**CPM Rat**	**Source/Notes**
380	08:22:36.77	+07:48:39.0	3.5	197.0	10.82	11.06	16	73							2000		WDS08226+0748 values per 08/2016
	125.65320600	7.8107830	3.43	197.3	10.42	11.03							1.30	E2	1998.782		2MASS. M1 and M2 estimated from J- and K-band
	125.65318333	7.8106528	3.25	198.4	10.43	10.76							0.31	C	2016.090		iT18 1x3s. Touching star disks
																	No objects for B in URAT1 and GAIA DR1

Table 1 continues on next page.

Jonckheere Double Star Photometry – Part V: Cancer

Table 1 (continued). J objects in Cancer

J#	RA	Dec	Sep "	PA °	M1	M2	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
381	08:31:22.08	+13:30:50.8	2.9	308.0	10.65	13.30	-4	-6							2005		WDS08314+1331 values per 08/2016
	127.84187900	13.5140490	2.92	317.5		15.61							2.50	Es	2005.096		SDSS DR9. Vmag M2 estimated from (gmag+rmag)/2
	127.84197083	13.5141417	2.54	308.7	10.55	12.27							0.31	C	2016.088		iT18 1x3s. Touching star disks. SNR B <20
																	No objects for B in 2MASS, URAT1 and GAIA DR1
J#	**RA**	**Dec**	**Sep"**	**PA°**	**M1**	**M2**	**pmRA1**	**pmDec1**	**e_pm1**	**pmRA2**	**pmDec2**	**e_pm2**	**Ap**	**Me**	**Date**	**CPM Rat**	**Source/Notes**
382	08:42:18.57	+08:56:57.2	4.2	44.0	9.30	10.60	-9	-19							2012		WDS08423+0857 values per 08/2016
	130.57742400	8.9492340	4.24	44.4	9.31								1.30	E2	2000.183		2MASS. M1 estimated from J- and K-band
	130.57738080	8.9491785	4.34	43.7			-10.37	-13.50	8.24	-8.35	-6.02	9.18	0.96	Hg	2015	CCCB	GAIA DR1. PM data calculated from position comparison with 2MASS - obviously no CPM
	130.57734583	8.9491639	4.27	43.1	9.55	11.42							0.31	C	2016.090		iT18 1x3s
J#	**RA**	**Dec**	**Sep"**	**PA°**	**M1**	**M2**	**pmRA1**	**pmDec1**	**e_pm1**	**pmRA2**	**pmDec2**	**e_pm2**	**Ap**	**Me**	**Date**	**CPM Rat**	**Source/Notes**
415	09:14:03.87	+09:07:59.8	4.2	59.0	9.50	9.60	-49	-26		7	10				2015		WDS09141+0906 values per 08/2016. WDS mags and PM data obviously wrong. Seems despite the rather small proper motion vector length a quite solid CPM candidate. The difference in PM vector length might suggest an orbit. The position error is in comparison with the PM vector length rather large, but the relationship separation to PM is only about 150 years
	138.51613100	9.1332360	4.13	57.4	12.26	12.25							1.30	E2	2000.143		2MASS. M1 and M2 estimated from J- and K-band
	138.51613800	9.1331990	4.21	57.2									2.50	Es	2002.953		SDSS DR9
	138.51603334	9.1331630	4.17	57.3			-23.36	-17.70	8.10	-21.15	-16.02	8.10	0.96	Hg	2015	ABCB	GAIA DR1. PM data calculated from position comparison with 2MASS
	138.51595833	9.1332333	4.15	57.7	12.05	12.29							0.31	C	2016.254		iT18 1x3s. SNR A and B <20

Table 1 continues on next page.

Table 1 (continued). J objects in Cancer

J#	RA	Dec	Sep"	PA°	M1	M2	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
732	08:02:11.93	+10:06:47.5	2.6	191.0	9.40	9.40	-5	-2							2008		WDS08023+1008 values per 08/2016
	120.54969717	10.1134345	2.58	191.8									0.96	Hg	2015		GAIA DR1
	120.54962083	10.1133861	2.82	189.1	12.18	12.76							0.31	C	2016.090		iT18 1x3s. SNR A <20 and B <10
																	No objects for B in 2MASS, SDSS and URAT1
J#	**RA**	**Dec**	**Sep"**	**PA°**	**M1**	**M2**	**pmRA1**	**pmDec1**	**e_pm1**	**pmRA2**	**pmDec2**	**e_pm2**	**Ap**	**Me**	**Date**	**CPM Rat**	**Source/Notes**
734	08:08:55.54	+07:49:41.1	1.9	237.0	10.80	11.56									2002		WDS08089+0750 values per 08/2016
	122.23128356	7.8280218	1.88	236.7									0.96	Hg	2015		GAIA DR1
	122.23079583	7.8280194	1.70	245.6	10.38	10.68							0.31	C	2016.088		iT18 1x3s. SNR B <20. Rather average large plate solving position error
																	No objects for B in 2MASS, SDSS and URAT1
J#	**RA**	**Dec**	**Sep"**	**PA°**	**M1**	**M2**	**pmRA1**	**pmDec1**	**e_pm1**	**pmRA2**	**pmDec2**	**e_pm2**	**Ap**	**Me**	**Date**	**CPM Rat**	**Source/Notes**
735	08:46:07.92	+07:48:20.2	2.8	340.0	10.15	10.18	-99	54		-99	53				2014		WDS08461+0748 values per 08/2016. WDS PM data suggests clearly CPM - this is not supported by the position comparison between 2MASS and GAIA DR 1. But as it seems the position for B in 2MASS might be completely off as is visually suggested in the 2MASS image with 2MASS catalog overlay - the position given here for B does certainly not correspond with the centroid of the star disk. Comparison of POSS I.O and POSS II.J images supports clearly CPM
	131.53305200	7.8053710	1.66	338.0	9.97	9.36							1.30	E2	2000.116		2MASS. M1 and M2 estimated from J- and K-band
	131.53271824	7.8055358	2.78	339.8			-79.98	39.87	10.26	-102.99	112.09	9.01	0.96	Hg	2015	CCCB	GAIA DR1. PM data calculated from position comparison with 2MASS - quite different in direction and speed, no CPM
	131.53265833	7.8055500	2.60	341.7	9.85	9.91							0.31	C	2016.090		iT18 1x3s. Touching star disks
J#	**RA**	**Dec**	**Sep"**	**PA°**	**M1**	**M2**	**pmRA1**	**pmDec1**	**e_pm1**	**pmRA2**	**pmDec2**	**e_pm2**	**Ap**	**Me**	**Date**	**CPM Rat**	**Source/Notes**
1002	08:07:24.95	+11:44:02.3	2.3	118.0	9.30	9.50	-15	-2		27	-6				2008		WDS08074+1145 values per 08/2016
	121.85399100	11.7339590	2.11	119.9									2.50	Es	2005.509		SDSS DR9
	121.85396928	11.7339333	2.28	118.3			-7.80	-9.42	7.24	11.12	-13.10	9.03	0.96	Hg	2015	CCCB	GAIA DR1. PM data calculated from position comparison with SDSS DR9 - obviously no CPM
	121.85393333	11.7339528	2.21	114.3	11.31	11.29							0.31	C	2016.088		iT18 1x3s. Touching star disks

Table 1 continues on next page.

Table 1 (continued). J objects in Cancer

J#	RA	Dec	Sep"	PA°	M1	M2	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
1007	08:36:47.77	+09:48:18.6	5.0	237.0	10.20	11.20	2	-21		-4	-23				2003		WDS08367+0948 values per 08/2016
	129.19906200	9.8051800	5.00	238.0	9.31								1.30	E2	2000.902		2MASS. M1 estimated from J- and K-band
	129.19904018	9.8051039	5.02	236.9			-5.49	-19.43	7.02	-3.07	-26.10	7.02	0.96	Hg	2015	CCCB	GAIA DR1. PM data calculated from position comparison with 2MASS. Rather no CPM even if the motion of both stars seems rather similar
	129.19901667	9.8051000	5.04	238.8	9.61	11.21							0.31	C	2016.254		iT18 1x3s. SNR B<20
J#	**RA**	**Dec**	**Sep"**	**PA°**	**M1**	**M2**	**pmRA1**	**pmDec1**	**e_pm1**	**pmRA2**	**pmDec2**	**e_pm2**	**Ap**	**Me**	**Date**	**CPM Rat**	**Source/Notes**
1009	09:07:27.89	+11:36:24.2	4.5	73.0	11.02	12.01	-21	-34		44	-10				2015		WDS09075+1136 values per 08/2016
	136.86624500	11.6067180	4.54	73.6	11.03	11.98							1.30	E2	2000.140		2MASS. M1 and M2 estimated from J- and K-band
	136.86614553	11.6065690	4.56	73.1			-23.61	-36.09	7.67	-23.28	-32.84	7.67	0.96	Hg	2015	ABCB	GAIA DR1. PM data calculated from position comparison with 2MASS - not a perfect CPM candidate but looks promising even if the error size in relation of the PM vector length is rather limited. Small difference in PM vector length might be a potential hint for an orbit
	136.86611667	11.6065833	4.59	72.4	11.01	12.23							0.31	C	2016.088		iT18 1x3s. SNR B<20
J#	**RA**	**Dec**	**Sep"**	**PA°**	**M1**	**M2**	**pmRA1**	**pmDec1**	**e_pm1**	**pmRA2**	**pmDec2**	**e_pm2**	**Ap**	**Me**	**Date**	**CPM Rat**	**Source/Notes**
1110	08:42:06.27	+25:00:43.4	3.4	42.0	9.92	10.24	-47	-21		-25	3				2012		WDS08421+2501 values per 08/2016
	130.52625500	25.0121710	2.71	42.5	9.10								1.30	E2	1998.092		2MASS. M1 estimated from J- and K-band
	130.52615740	25.0120864	3.41	41.2									0.20	Eu	2000.580		UCAC4. Date is calculated mean epoch
	130.52594389	25.0120214	3.41	41.8			-60.03	-31.86	9.20	-33.99	0.12	6.69	0.96	Hg	2015	CCCA	GAIA DR1. PM data calculated from position comparison with 2MASS - obviously no CPM. But the 2MASS position data seems a bit off
							-46.03	-17.70	1.805	-42.15	-20.99	1.117	0.96	Hg	2015	CCAA	GAIA DR1. This is one of the so far rare cases with PM data for both components directly in the GAIA catalog. While these values give to some degree the impression of potential CPM they are not close enough for such a conclusion: Delta PM vector direction is more than 5° and difference in PM vector length is near 5%. We have also given the parallax with 5.91mas for A and 5.94mas for B with an error of 0.37 and 0.38mas indicating that the distance between these two stars might be less than 1 parsec but with the given error range probably much more
	130.52597917	25.0119778	3.41	44.2	9.72	10.11							0.31	C	2016.090		iT18 1x3s

Table 1 concludes on next page.

Table 1 (conclusion). J objects in Cancer

J#	RA	Dec	Sep"	PA°	M1	M2	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
2051	07:59:52.11	+13:06:35.1	6.0	131.0	11.10	12.00	-14	3		27	-27				2013		WDS08000+1307 values per 08/2016
	119.96663300	13.1101310	5.88	130.2	13.05	14.21							1.30	E2	1997.836		2MASS. M1 and M2 estimated from J- and K-band
	119.96663500	13.1101397	5.90	130.3	12.83		0.44	1.97	5.35	1.24	0.27	5.27	0.20	Eu	2013.825	CCCC	URAT1. PM data calculated from position comparison with 2MASS - obviously no CPM
	119.96663045	13.1101383	5.91	130.2			-0.52	1.53	4.94	0.86	-0.10	4.94	0.96	Hg	2015	CCCC	GAIA DR1. PM data calculated from position comparison with 2MASS - obviously no CPM
	119.96654167	13.1101639	6.36	129.9	13.08	14.40							0.61	C	2016.859		iT24 5x3s
J#	RA	Dec	Sep"	PA°	M1	M2	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
2063	08:45:35.34	+09:16:03.2	7.9	115.0	12.63	12.74	-3	-5		-5	-8				2000		WDS08456+0915 values per 08/2016. Note Code "B" for blue magnitudes
	131.39701300	9.2673590	7.84	114.4	11.01	12.12							1.30	E2	2000.116		2MASS. M1 and M2 estimated from J- and K-band
	131.39695145	9.2673410	7.72	115.1			-14.69	-4.34	5.70	-24.80	-6.61	5.70	0.96	Hg	2015	ACCB	GAIA DR1. PM data calculated from position comparison with 2MASS - PM values too small to be significant, but CPM possi-ble, potentially with orbit
	131.39691667	9.2673333	7.78	115.1	10.94	12.06							0.31	C	2016.254		iT18 1x3s
J#	RA	Dec	Sep"	PA°	M1	M2	pmRA1	pmDec1	e_pm1	pmRA2	pmDec2	e_pm2	Ap	Me	Date	CPM Rat	Source/Notes
2067	09:09:45.10	+08:47:48.3	10.8	343.0	11.74	12.87	-1	-3		3	63				2015		WDS09100+0849 values per 08/2016
	137.43793700	8.7967680	9.91	340.2	12.17	13.41							1.30	E2	2000.140		2MASS. M1 and M2 estimated from J- and K-band
	137.43791476	8.7967958	10.73	342.3			-5.32	6.74	6.66	2.08	67.29	6.66	0.96	Hg	2015	CCCB	GAIA DR1. PM data calculated from position comparison with 2MASS - obviously no CPM
	137.43795833	8.7967472	10.97	342.2	12.25	13.22							0.31	C	2016.088		iT18 1x3s

Explanations Notes column:

- "iT28 1x3s" indicates the use of telescope iT18 images with 3s exposure time and use of URAT1 for plate solving
- "iT24 5x3s" indicates the use of stacked telescope iT24 images with 3s exposure time and use of URAT1 for plate solving
- "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 (one of them might be objects with fast proper motion not or wrong given in URAT1). But this is already included in the calculation of the error range estimation

Appendix A

Table 2 gives the plate solving errors for the used images and error information derived from the measurements reported in Table 1 and also the measured positions for both components.

Table 2: Error estimations for the in table 1 provided measurements for the given objects:

Name		RA	Dec	dRA	dDec	Err_Sep	Err_PA	Err_Mag	SNR	dVmag
J 46	A	07 55 39.135	12 40 08.51	0.09	0.15	0.175	4.336	0.063	54.54	0.06
	B	07 55 38.980	12 40 08.93					0.069	31.97	
J 73	A	08 25 57.584	07 49 08.50	0.07	0.11	0.130	1.967	0.071	124.06	0.07
	B	08 25 57.431	07 49 05.46					0.076	37.66	
J 76	A	09 00 18.894	09 17 18.05	0.05	0.08	0.094	1.217	0.093	43.80	0.09
	B	09 00 18.596	09 17 17.55					0.118	13.76	
J 77	A	09 05 04.676	10 29 22.87	0.08	0.10			0.051	108.89	0.05
	B									
J 375	A	08 08 54.749	12 12 27.41	0.06	0.10	0.117	0.696	0.096	30.88	0.09
	B	08 08 55.040	12 12 18.81					0.098	27.07	
J 375	A	08 08 54.749	12 12 27.41	0.06	0.10	0.117	0.447	0.096	30.88	0.09
	C	08 08 54.607	12 12 42.21					0.125	11.98	
J 376	A	08 09 16.477	12 03 31.47	0.09	0.10	0.135	3.868	0.116	29.69	0.11
	B	08 09 16.343	12 03 31.78					0.121	20.82	
J 377	A	08 14 10.493	06 59 42.77	0.09	0.09	0.127	4.297	0.091	24.53	0.08
	B	08 14 10.474	06 59 44.44					0.248	4.15	
J 380	A	08 22 36.764	07 48 38.35	0.07	0.12	0.139	2.451	0.102	53.71	0.10
	B	08 22 36.695	07 48 35.27					0.104	39.90	
J 381	A	08 31 22.073	13 30 50.91	0.05	0.08	0.094	2.125	0.093	44.56	0.09
	B	08 31 21.937	13 30 52.50					0.133	10.61	
J 382	A	08 42 18.563	08 56 56.99	0.08	0.13	0.153	2.046	0.082	66.05	0.08
	B	08 42 18.760	08 57 00.11					0.095	21.08	
J 415	A	09 14 03.830	09 07 59.64	0.23	0.19	0.298	4.109	0.129	15.41	0.11
	B	09 14 04.067	09 08 01.86					0.148	10.53	
J 732	A	08 02 11.909	10 06 48.19	0.07	0.09	0.114	2.319	0.108	17.46	0.09
	B	08 02 11.879	10 06 45.41					0.184	6.27	
J 734	A	08 08 55.391	07 49 40.87	0.37	0.28	0.464	15.296	0.079	28.53	0.07
	B	08 08 55.287	07 49 40.17					0.099	15.06	
J 735	A	08 46 07.838	07 48 19.98#	0.10	0.22	0.242	5.307	0.093	43.75	0.09
	B	08 46 07.783	07 48 22.45					0.094	42.01	
J 1002	A	08 07 24.944	11 44 02.23	0.06	0.08	0.100	2.593	0.089	27.47	0.08
	B	08 07 25.081	11 44 01.32					0.087	30.62	
J 1007	A	08 36 47.764	09 48 18.36	0.13	0.14	0.191	2.169	0.094	37.28	0.09
	B	08 36 47.472	09 48 15.75					0.114	15.15	
J 1009	A	09 07 27.868	11 36 23.70	0.06	0.09	0.108	1.349	0.105	34.36	0.10
	B	09 07 28.166	11 36 25.09					0.129	12.87	
J 1110	A	08 42 06.235	25 00 43.12	0.05	0.09	0.103	1.727	0.072	59.63	0.07
	B	08 42 06.410	25 00 45.57					0.074	45.08	
J 2051	A	07 59 51.970	13 06 36.59	0.11	0.10	0.149	1.339	0.064	47.95	0.06
	B	07 59 52.304	13 06 32.51					0.076	22.67	
J 2063	A	08 45 35.260	09 16 02.40	0.10	0.10	0.141	1.041	0.113	40.60	0.11
	B	08 45 35.736	09 15 59.10					0.120	21.79	
J 2067	A	09 09 45.110	08 47 48.29	0.06	0.11	0.125	0.654	0.122	19.76	0.11
	B	09 09 44.884	08 47 58.74					0.143	11.43	

- dRA and dDec = average RA and Dec plate solving errors in arcseconds
- Err_Sep = separation error estimation in arcseconds calculated as SQRT(dRA^2+dDec^2)
- Err_PA = position angle error estimation in degrees calculated as arctan (Err_Sep/Sep) assuming the worst case that Err_Sep points perpendicular to the separation vector
- dVmag as average mag plate solving error (Vmag for images with made V-filter and Imag for images made with I-filter)
- Err_Mag = magnitude error estimation calculated as SQRT(dVmag^2+(2.5*LOG10(1+1/SNR))^2)
- SNR as signal to noise ratio for the given object

Appendix B

CPM rating scheme according to Knapp/Nanson 2016 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 pf 2MASS) with the consequence that the requirements to get an A or even B CPM rating get unreasonablely 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.