Measurements of 10 Neglected Pairs

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Abstract.

Separation (*ρ*) and Position Angle (*θ*) measurements are reported for 10 pairs for which measures where last reported in the WDS +20 years from epoch of observation 2021.066. Measurements were obtained by fast and lucky imaging and are presented with associated measurement uncertainties, as well as comparisons to measurements determined from Gaia DR2 & EDR3 and historic data extrapolation at epoch of J2000.0.

1.0 Observations.

Instrumentation

The 14-inch Schmidt-Cassegrain located at the Kirby observatory owned by the University of New England was used to make the observations in this work. The camera used for the observation was a ZWO ASI-120MM-S monochrome CMOS camera fitted with a Wratten #25 red filter.

Software & Data Acquisition

The capture software Sharpcap (Glover, 2017) was used for the observations. Observational data were processed in the *Reduc* software. The pixel scale was determined by reference pair calibration using direct imaging of α Cen AB in *Reduc* which produced a 0.1766 as/px scale; the same calibration used previous works (James, 2019 & 2020). The camera rotation was computed using the *Synthetic Drift* function. The *AutoReduc* function was then used and all images outside 2 standard deviations from the mean of *PA* and *ρ*, were rejected from this work. The *Aladin Sky Atlas* and the *SIMBAD* astronomical database was used to source the Gaia data.

Selection of Pairs

The 10 pairs in this work were sourced from the Washington Double Star (WDS) Catalog with the requirements that the pairs had a last recorded separation greater than 4 arcseconds, a last recorded observation greater than 20 years, that the secondary was brighter than magnitude 10 and that the delta magnitude was less than 2.5. The exceptions were the close pair 06387-4504 HJ 3882AB (separated by less than 2 arcseconds) which was detectable while observing 06387-4504 HJ 3882AC, and 08057-3334 HJ 4046AC (*Δmag* ≈ (4.39,4.74); Gaia Collaboration, *et al.*) as it was presented in a private communication (Damm, 2018).

2.0 Astrometric Measures

This work was conducted on epoch of observation 2021.066. All pairs, excluding 06387-4504 HJ 3882AC (1991) and 08057-3334 HJ 4046AC (2015), were last updated in the WDS in 1999. Table 1 presents the measurements of *θ* and *ρ* with their associated standard error on the mean (SEM).

Table 1: *θ* and *ρ* determined from observations at epoch 2021.066.

#	WDS	DISC	θ (deg)	θ SEM (deg)	ρ (arcsec)	ρ SEM (arcsec)
1	06018-4110	HJ 3827AB,C	239.86	0.007	23.844	0.003
2	06387-4504	HJ 3882AB	28.23	0.252	1.942	0.011
3	06387-4504	HJ 3882AC	331.53	0.076	17.992	0.020
4	06393-3150	VOU 21A,BC	27.81	0.018	23.752	0.008
5	06443-3219	COO 43	264.52	0.071	4.719	0.007
6	07289-3151	DUN 49	53.89	0.029	8.932	0.007
7	07341-5050	HJ 3986	220.08	0.013	49.517	0.013
8	08057-3334	HJ 4046AB	88.43	0.017	22.061	0.007
9	08057-3334	HJ 4046AC	60.42	0.062	27.911	0.028
10	08057-3334	I 189BC	9.68	0.103	13.363	0.024

3.0 Extrapolated Historical Measurements.

Measures of θ and *ρ* were determined by linear extrapolation from historic observations (sourced from Brian Mason of the UNSO) which also included *θ* and *ρ* measurements from this work and Gaia at epoch J2000.0. Precession based on the proper motion of the historical observation to J2000.0 was performed.

Based on the size of separation, relatively small proper motion, and few reported observations, a linear extrapolation was justified. As an aside, extrapolation of pairs from non-linear curve fitting with smaller separations and larger proper motions can be more accurate, especially over centuries of measurements.

The first listed historic observations of the pairs 06018-4110 HJ 3827AB,C, 06387-4504 HJ 3882AC, 06443-3219 COO 43, 08057-3334 I 189BC were regarded as obvious outliers and not used to compute the measures or uncertainties in this work.

Historical uncertainties were estimated from (White, Letchford, & Ernest, 2018), which estimates the accuracy of *θ* and *ρ* measurements of Alpha Centarui AB (α Cen AB) over the past ~270 years. α Cen AB is a well observed and modelled pair, and with this knowledge, the historical uncertainties presented here are likely smaller than the actual uncertainties of each historical *θ* and *ρ* measurement.

Table 2: *PA* and *ρ* linearly extrapolated to epoch of J2000.0. Extrapolation includes historic data, this work and Gaia measurements. * indicates a private communication (Damm 2018).

#	WDS	# obs	First Obs	Last Obs	θ (deg)	θ SEM (deg)	ρ (arcsec)	ρ SEM (arcsec)
1	06018-4110	13	1837	1999	240.49	0.83	23.68	0.25
2	06387-4504	6	1913	1991	26.23	1.00	1.90	0.28
3	06387-4504	17	1835	1999	331.40	1.77	17.96	0.30
4	06393-3150	10	1911	1999	27.89	0.89	23.77	0.13
5	06443-3219	13	1911	1999	264.39	0.81	4.77	0.19
6	07289-3151	29	1835	1999	53.81	1.26	8.68	0.44
7	07341-5050	11	1836	1999	219.78	0.80	47.69	0.23
8	08057-3334	16	1837	1999	88.32	1.15	22.06	0.37
9	08057-3334	5	1903	2015*	60.08	0.69	27.84	0.20
10	08057-3334	6	1897	1999	9.30	0.74	14.03	0.24

4.0 Gaia Measurements

Gaia position and proper motion measurements were sourced from the SIMBAD astronomical database and *Aladin Sky Atlas*. Gaia θ and ρ measures presented in Table 3 have been precessed to epoch of equinox J2000.0 for comparison with the observation presented in this work and historic extrapolations (Figure 1), and to estimate accuracy using the micro-arcsecond precision of the Gaia position measurements as a standard for comparison.

Table 3: θ and ρ based on Gaia data at epoch of observation.

#	Comp	Gaia ID	Gaia data release	θ (deg)	θ δ (deg)	ρ (arcsec)	ρ δ (arcsec)
1	A	2882343210792764544	Gaia EDR3	239.024	0.005	23.693	0.014
	B	2882343210794006656					
	C	2882343107714792448					
2	A	5556069272925158656	Gaia DR2	25.137	<0.001	1.897	0.224
	B	5556069272923110000					
3	A	5556069272925158656	Gaia DR2	331.375	0.010	18.007	0.020
	C	5556069479083586688					
4	A	5583873241933194496	Gaia EDR3	27.936	0.070	23.751	0.031
	B	5583873310652668160					
	C	5583873310651519104					
5	A	5583926636967008384	Gaia DR2	264.324	0.024	4.801	0.123
	B	5583926735748050944					
6	A	5593011729755869696	Gaia DR2	53.700	0.025	8.923	0.041
	B	5593011832835083008					
7	A	5493532792450982144	Gaia DR2	219.817	0.001	48.376	0.014
	B	5493532693670905088					
8	A	5546088112536703488	Gaia DR2	88.187	0.008	22.071	0.010
	B	5546088112527125632					
9	A	5546088112536703488	Gaia DR2	59.904	0.006	27.903	0.010
	B	5546088112536693376					
10	B	5546088112527125632	Gaia DR2	8.897	0.054	13.456	0.175
	C	5546088112536693376					

5.0 Measurement Bias.

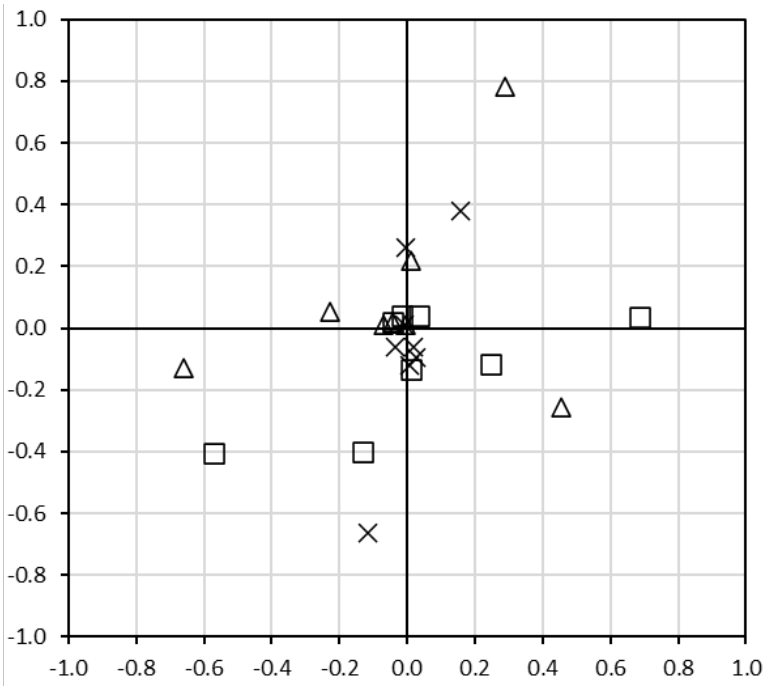
Figure 1 presents the differences in θ and ρ measurements from this work, Gaia DR2 and EDR3, and historical data; all at J2000.0. The largest discrepancies were caused by 06387-4504 HJ 3882AB due to the small separations involved, and 08057-3334 HJ 4046AC with a large delta magnitude. These pairs where removed from Figure 1, however are present in Table 1.

Table 4 shows the mean difference between the observations in this work, Gaia, and historic data (column 1). Columns 2 and 3 are the mean differences of θ and ρ. Columns 4 and 5 are the same but with 06387-4504 HJ 3882AB and 08057-3334 HJ 4046AC measurements removed from the calculation.

Table 4: Accuracy of measurements

	θ (deg)	*ρ (arcsec)*	*θ (deg)*	*ρ (arcsec)*
Gaia – This Work	-0.367	-0.008	-0.044	0.006
Hist – This Work	-0.135	-0.045	-0.089	-0.031
Gaia – Hist	-0.234	0.028	-0.115	0.027

Figure 1: Plot of the difference in measures at epoch 2021.066. Gaia - This Work (X), Hist - This Work (□), Gaia - Hist (△). θ (deg) on the vertical axis and ρ (arcsec) on the horizontal axis.



Summary & Conclusion.

Presented are θ and ρ measures of 10 scarcely observed pairs. A comparison with Gaia DR2 & EDR3 data, and linear extrapolations of historic measurements was conducted as a check on the bias and accuracy in this work.

It was determined that the difference in measures for this work was -0.367 deg and 0.008 arcseconds for θ and ρ respectively when compared to Gaia observations, and -0.135 deg and -0.045 arcseconds for θ and ρ respectively when compared to historic data. With the two pairs 06387-4504 HJ 3882AB (separated by less than 2 arcseconds) and 08057-3334 HJ 4046AC ($\Delta mag \approx (4.39,4.74)$) removed, these differences significantly improve and show the measures presented in this work with respect to GAIA DR2 & EDR3 are in good agreement.

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