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SPECKLE INTERFEROMETRY AT THE U.S. NAVAL OBSERVATORY. XIV.

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ABSTRACT

The results of 2033 intensified CCD observations of double stars, made with the 26 inch refractor of the U.S. Naval Observatory, are presented. Each observation of a system represents a combination of over 2000 short-exposure images. These observations are averaged into 1297 mean relative positions and range in separation from 0$''$.54 to 58$''$.96, with a mean separation of 14$''$.99. This is the 14th in this series of papers and covers the period 2007 January 17 through 2007 December 31. The first two resolutions of closer companions to previously known wider pairs are also presented.

Key words: binaries : general – binaries : visual

Online-only material: machine-readable and VO tables

1. INTRODUCTION

This is the 14th in a series of papers from the U.S. Naval Observatory's (USNO) speckle interferometry program, presenting results of observations obtained at the USNO 26 inch telescope in Washington, DC. Over 21,000 measures have now resulted from this program since its inception by Charles Worley, Geoff Douglass, and colleagues in the early 1990s (see Douglass et al. 1997).

From 2007 January 17 through 2007 December 31, the 26 inch telescope was used on 79 of 237 (33%) scheduled nights. While most nights were lost due to weather conditions, time was also lost due to equipment upgrades and personnel observing on other telescopes. Since our primary speckle camera was in use at other facilities during this period, all of these observations were obtained with the secondary camera, described by Mason et al. (2007).

Most of the systems observed with this camera have separations well beyond the regime in which there is any expectation of isoplanicity, so we classify the observing technique for all of these measures as just "CCD astrometry," rather than speckle interferometry. Despite this classification, there is an expectation that the resulting measurements have smaller errors than classical CCD astrometry. Each measurement is the result of many hundreds of correlations per frame, and up to several thousand frames per observation. This ensemble of observations is then processed and measured using the conventional directed vector autocorrelation techniques used by the Center for High Angular Resolution Astronomy (CHARA) and USNO speckle teams for over 20 years.

While individual nightly totals varied substantially (from two to 70 objects per night), the results yielded 2593 observations and 2324 resolutions (i.e., usable double star measurements). After removing marginal observations, calibration data, and tests, a total of 2033 measurements remained which were grouped into 1297 mean positions. Included in these are 84 confirmations of binaries that had only one previous observation. While some of these are relatively recent discoveries of the *Hipparcos* or Tycho missions (ESA 1997), some of these pairs had remained unconfirmed for over 100 years.

Observing-list construction and calibration procedures remain the same as those described for the "secondary" camera in Mason et al. (2007). The plate scale of the secondary camera is not appropriate for the slit-mask calibration used in Mason et al. (2007) for the primary camera. This method also allowed us to use double stars to evaluate system accuracy and precision. Evaluation of the ensemble of the tabulated $O-C$ allows the error in θ and ρ to be grossly characterized as $\pm 1^{\circ}.0$ and $\pm 1\%$, respectively.

2. RESULTS

Table 1 presents coordinates and magnitude information from the Centre de Données Astronomiques de Strasbourg (CDS)[1] for two binaries which are measured here for the first time; both were found as closer, additional components to known pairs. Column (1) gives the coordinates of the primary of the pair. Column (2) is the discoverer designation (where WSI = Washington Stellar Interferometer) number. Columns (3) and (4) give the estimated visual magnitudes of the primary and secondary, respectively, of the pair described here, and Column (5) notes the circumstance of the discovery. The mean double star positions (T, θ, and ρ) of these systems are given in Table 2.

Table 2 presents the mean relative position of the members of 850 systems having no published elements. The first two columns identify the system by providing its epoch-2000 coordinates and discovery designation. Columns (3)–(5) give the epoch of observation (expressed as a fractional Besselian year), the position angle (in degrees), and the separation (in seconds of arc), respectively. Note that the position angle has not been corrected for precession, and is thus based on the equinox for the epoch of observation. Objects whose measures are of lower quality are indicated by colons following the position angle and separation. The lower-quality of these observations may be due to one or more of the following factors: close separation, large Δm, one or both components being very faint, a large zenith distance, and poor seeing or transparency. They are included primarily due to either the confirming nature of the observation or the number of years since the last measured position. The sixth column indicates the number of independent measurements (i.e., observations obtained on different nights) contained

[1] Magnitude information is from the Aladin sky atlas, operated at CDS, Strasbourg, France

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Table 1
New WSI pairs

Coordinates α, δ (2000) (1)	Discoverer Designation (2)	$\mathrm{Mag}_{\mathrm{primary}}$ (est.) (3)	$\mathrm{Mag}_{\mathrm{secondary}}$ (est.) (4)	Note (5)
07 48 47.13 +14 36 22.1	WSI 25 AB	10.9	11.4	1
19 20 52.85 +23 03 48.8	WSI 26 BC	10.9	10.9	2

Notes.
1: closer pair found while searching for and measuring HJ 3300 = 07487+1436. See Table 2. The previously known pair is now designated AC.
2: closer pair found while searching for and measuring SLE 937 = 19209+2304. See Table 2.

Table 2
ICCD Measurements of Double Stars

WDS Designation α, δ (2000)	Discoverer Designation			Epoch 2000.+	θ (°)	ρ ($''$)	n	Note
00026 + 6606	STF	3053		7.807	70.3	15.00	1	
00040 + 6050	HJ	1930		7.990	166.3	10.92	2	
00076 − 1825	HJ	3240		7.730	130.5	7.57	1	
00113 + 2953	MLB	631		7.916	270.9	8.39	1	
00115 + 2949	MLB	441		7.916	358.6	14.36	2	
00115 + 2949	MLB	441	BC	7.916	343.0	36.68	1	
00140 + 2837	BRT	117		7.916	68.3	5.26	2	
00140 + 2837	MLB	554	AC	7.916	49.1	29.88	1	
00150 + 0849	STF	12		7.984	147.6	11.30	4	
00153 − 1133	SLE	251		7.730	191.9	21.27	1	

Notes.
C : confirming observation.
O : based on proper motion of the primary and the time since the last observation, this pair appears to be optical.
P : based on proper motion of the primary and the time since the last observation, this pair appears to be physical.
1 : partial elements in Hopmann (1967).
2 : also known as TDS2606.
3 : poor agreement with the 1895 discovery measure ($\Delta\theta = 64$ deg, $\Delta\rho = 3\farcs6$) is apparently due to a typographical error in the Potsdam Observatory Catalog used by Scheiner (1908) for extracting possible doubles. Matches by GLW to other Astrographic Catalog plates from 1929 and 1930 are in good agreement ($3\fdg3$, $0\farcs74$) with the present measure. The discrepancy cited here was noted by E. Wiley (private communication, 2007).
4 : new, closer pair to a known double. See Table 1.
5 : partial elements in Hopmann (1960b).
6 : partial elements in Zeller (1965).
7 : pair noted by I. Coster (private communication, 2007) while investigating SHR1. This is the first measure of this pair.
N = 50−187 : number of years since last measure.

(This table is available in its entirety in machine-readable and Virtual Observatory (VO) forms in the online journal. A portion is shown here for guidance regarding its form and content.)

in the mean, and the seventh flags any notes. The 850 measurements in Table 2 have a mean separation of $13\farcs70$.

The most common note indicators are either "C," indicating a confirming observation, or a number (N) indicating the number of years since the system was last measured. This is only given for systems with $N \geqslant 50$ years. Eighty-four systems are confirmed here. Since priority is given to both unconfirmed systems and to systems not observed recently, the time since last observation can be surprisingly large; for the systems in Table 2 the average time since the last observation is 18 years (80 years for those measures of reduced accuracy). One hundred sixty systems had not been observed in 50 years or more and 38 had not been observed for at least a century. The maximum such time span was 187 years for the pairs HJ 458, HJ 829, and HJ 162, which were all first (and last) observed by John Herschel in 1820 (Herschel 1826, 1829). The long delay in confirming these historic pairs was simply due to poor coordinates—most had only arcminute-precise published coordinates, precessed without proper motion correction from the original coarse epoch-1820 α and δ.

Table 3 presents the mean relative positions for 447 binary star systems with published orbital determinations or linear solutions. The first six columns are identical to the corresponding columns of Table 2. Columns (7) and (8) give $O-C$ residuals (in θ and ρ, respectively) to the determination referenced in Column (9). The reference is either to a published orbit or a **L**, which would indicate a determination in the "Catalog of Rectilinear Elements" (Hartkopf et al. 2006). The objects in Table 3 tend to be more frequently observed than those in Table 2, with a mean separation of $17\farcs45$, and a mean time interval since last observation of only 2.6 yr. The system 21124−1500 (=H 1 47) also has an orbit calculation by Hopmann (1974). The residuals to it are so large that the orbital solution is obviously in error and the linear fit cited is the best solution for the pair.

3. PHYSICAL OR OPTICAL?: COMMON PROPER MOTION CHARACTERIZATION

For those long-neglected wide doubles whose primaries have a large proper motion, a single new observation can occasionally allow us to determine whether the components share a common proper motion (CPM). These pairs are sufficiently wide such that only negligible orbital motion would be expected; therefore, recovery with relatively unchanged values of ρ and θ allows the CPM determination to be made. These systems are easiest to exploit when the combination of primary proper motion and time since last observation yields a change in position significantly greater than the expected error of observation, i.e.,

$$\sqrt{PM_\alpha^2 + PM_\delta^2} * T \geqslant 30\%\rho,$$

where PM_α and PM_δ represents the proper motion in right ascension and declination, respectively, and T is the time since the last observation. This change in proper motion of the primary is evaluated against a 30% of the measured separation (ρ). Making 30%ρ equal to the error is almost certainly several factors, and possibly an order of magnitude, too large; however, without an individual assessment of all the relevant observations, this value is selected to give near certain assessment. Based on this analysis, of the pairs in Table 2, 14 are identified as optical and one is identified as physical (i.e., CPM). These are indicated in Table 2 with notes.

4. DOUBLE STARS NOT FOUND

Table 4 presents six systems which were observed but not detected. Possible reasons for nondetection include orbital or differential proper motion making the binary too close or too wide to resolve at the epoch of observation, a larger than expected Δm, incorrect pointing, and misprints and/or errors in the original reporting paper. It is hoped that reporting these will encourage other double star astronomers to either provide

Table 3
Measurements of Systems with Orbits or Rectilinear Solutions

WDS Designation $\alpha\delta$ (2000)	Discoverer Designation			Epoch 2000.+	θ (°)	ρ ($''$)	n	$O-C$ (°)	$O-C$ ($''$)	Reference
00032+4508	HJ	1927		7.897	73.2	9.99	2	0.5	−0.09	**L**
00057+4549	STT	547	AB	7.913	185.1	6.06	3	−0.4	0.11	Popovic & Pavlovic (1996)
								−0.0	0.00	Kiyaeva et al. (2001)
00175+0019	STF	23	AB	7.730	218.0	9.26	1	−0.6	−0.08	**L**
00187+2545	HJ	1015	AB	7.730	291.1	5.42	1	5.3	0.28	**L**
00272+4959	STF	30	AB	7.897	313.0	13.63	2	−1.2	−0.03	**L**
00305+2208	HJ	1027		7.687	216.7	17.92	1	−0.4	−0.81	**L**
00378+2443	J	923		7.687	264.8	21.40	1	−0.1	0.02	**L**
00384+4059	STF	44		7.678	273.6	12.54	2	0.1	−0.03	**L**
00409+3301	SEI	7	AB	7.687	170.8	15.02	1	0.1	−0.03	**L**

(This table is available in its entirety in machine-readable and Virtual Observatory (VO) forms in the online journal. A portion is shown here for guidance regarding its form and content.)

Table 4
Double Stars Not Found

Coordinate α, δ (2000)	Discoverer Designation			Most Recent Published Observation: Date	Position Angle (θ)	Separation (ρ)	Published Magnitude: Primary	Secondary	Notes
17053+1947	SLE	6		1982	137	20.3	9.5	11.0	
17222+2605	SLE	23	AD	1982	91	24.1	9.4	9.8	
18130−1819	TDT	739		1991	253	2.2	10.8	11.7	
18515+1507	OL	105		1921	146	2.7	10.8	11.8	1
18585+1523	OL	216		1947	299	3.0	10.8	11.4	
19326+3434	SEI	622		1895	153	12.1	11.0	11.0	

Note. 1: also not found by Heintz (1985).

corrections to the USNO observations or to verify the lack of detection.

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