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

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ABSTRACT

The results of 3362 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 1970 mean relative positions and range in separation from 0′′.78 to 72′′.76, with a mean separation of 14′′.76. This is the 17th in this series of papers and covers the period 2010 January 6 through December 20. Also presented are 10 pairs that are resolved for the first time.

Key words: binaries: general – binaries: visual

Online-only material: machine-readable and VO tables

1. INTRODUCTION

This is the 17th in a series of papers from the U.S. Naval Observatory’s speckle interferometry program, presenting results of observations obtained at the USNO 26 inch telescope in Washington, DC. Over 24,000 mean positions 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 2010 January 6 through December 20, the 26 inch telescope was used on 77 of 257 (30%) scheduled nights. Most nights were lost due to weather conditions, but time was also lost due to equipment upgrades, mechanical issues, and to 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). As described in Mason et al. (2011), the ICCD used on our secondary or “backup” camera failed at the end of 2008 and our primary camera was used in its place. In late 2009 a replacement ICCD was procured; following a testing/verification phase this new ICCD was installed on the primary camera head and the older ICCD was installed on the secondary camera head. To within detectable errors the sensitivity, pixel ratio, and capabilities of the new ICCD are identical with the older unit. The new ICCD and primary camera head were subsequently shipped to Cerro Tololo for observations on the CTIO 4 m.

Most of the systems observed with this camera have separations well beyond the regime in which there is any expectation of isoplanicly. These images are almost direct CCD imaging observations, but utilize the short exposure time and a variant of the autocorrelation reduction method to generate a two-dimensional autocorrelagram. Each measurement is the result of many hundreds of correlations per frame, and up to several thousand frames per observation.

While individual nightly totals varied substantially (from 8 to 101 objects per night, mean = 43.7, median = 45) the results yielded 3362 observations and 3261 resolutions (i.e., usable double star measurements). After removing marginal observations, calibration data, and tests, a total of 3093 measurements remained, which were grouped into 1963 mean positions. Included in these are 45 confirmations of double stars with only one previous observation. While 14 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 this camera is not appropriate for the slit-mask calibration used in Mason et al. (2007) for the primary camera, so well-observed double stars are used to evaluate system accuracy and precision. Evaluation of the ensemble of tabulated $O-C$ values in Table 3 allows the error to be grossly characterized as $\pm 1.0$ and $\pm 1\% \rho$.

2. RESULTS

2.1. New Pairs

Table 1 presents coordinates and magnitude information from CDS for 10 pairs which are measured here for the first time. All were observed as closer components to known systems or in the same field of view. 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 of the pair described here, and Column 5 notes the circumstance of the discovery. The mean relative astrometry ($T, \theta,$ and $\rho$) of these systems is given in Table 2.

2.2. Measures of Known Pairs

Table 2 presents the mean relative positions of the members of 1588 systems having no published orbital or linear elements. The first two columns identify the system by providing its epoch-2000 coordinates and discovery designation. Columns 3 through 5 give the epoch of observation (expressed as a fractional Besselian year), the position angle (in degrees), and the separation (in seconds of arc). Note that the position angle has not been corrected for precession or nutation, and is thus based on the true equinox for the epoch of observation.

1 Magnitude information is from the Aladin sky atlas, operated at CDS, Strasbourg, France.
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14. ABSTRACT  
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Table 1  
New WSI Pairs

<table>
<thead>
<tr>
<th>Coordinates</th>
<th>Discoverer</th>
<th>Mag&lt;sub&gt;primary&lt;/sub&gt; (est.)</th>
<th>Mag&lt;sub&gt;secondary&lt;/sub&gt; (est.)</th>
<th>Note</th>
</tr>
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<tr>
<td>α, δ (2000)</td>
<td>WSI 42 AC</td>
<td>10.2</td>
<td>11.1</td>
<td>1</td>
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<tr>
<td>00 45 08.08 + 64 23 31.1</td>
<td>WSI 29 BC</td>
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<td>13.0</td>
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<td>03 57 12.93 + 32 00 42.6</td>
<td>WSI 27</td>
<td>10.9</td>
<td>12.5</td>
<td>3</td>
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<tr>
<td>07 10 23.30 − 12 21 58.0</td>
<td>WSI 28</td>
<td>10.6</td>
<td>10.7</td>
<td>4</td>
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<tr>
<td>09 16 02.27 −14 01 50.5</td>
<td>WSI 35 AD</td>
<td>10.8</td>
<td>12.5</td>
<td>5</td>
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<td>17 01 01.00 + 68 05 06.9</td>
<td>WSI 30</td>
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<td>6</td>
</tr>
<tr>
<td>19 14 58.39 + 38 32 10.9</td>
<td>WSI 46 AC</td>
<td>11.0</td>
<td>13.6</td>
<td>7</td>
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<tr>
<td>20 51 53.87 + 33 27 09.3</td>
<td>WSI 47 AC</td>
<td>9.5</td>
<td>12.8</td>
<td>8</td>
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<tr>
<td>23 24 15.83 + 61 35 17.5</td>
<td>WSI 48 AE</td>
<td>8.4</td>
<td>12.3</td>
<td>9</td>
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<tr>
<td>23 39 44.25 + 78 41 31.0</td>
<td>WSI 41</td>
<td>10.2</td>
<td>10.3</td>
<td>10</td>
</tr>
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</table>

Notes. (1) New pair discovered in the same field of view as 00452 + 6424 ST1 123. (2) B component of 03572 + 3201 SEI 33 discovered as closer pair. Measure of AC and BC given in Table 2. (3) Find while searching for 07103−1222 BRT2661. May be a common-proper-motion companion. (4) Found while searching for 09167−1407 BRT2716. May be a common-proper-motion companion. (5) New component of 17010 + 6807 MLR 199 discovered closer than known pair. Measure weak, but companion seen repeatedly. (6) New component of 17010 + 6807 STI 123. (7) New component of 17010 + 6807 HJ 3233 10.783 236.5 19.82 2 |

Table 2  
ICCD Measurements of Double Stars

<table>
<thead>
<tr>
<th>WDS Design.</th>
<th>Discoverer</th>
<th>Epoch θ</th>
<th>ρ</th>
<th>n</th>
<th>Note</th>
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<td>00005 + 6713</td>
<td>HI 1924</td>
<td>10.884</td>
<td>225.1</td>
<td>8.20</td>
<td>2</td>
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<tr>
<td>00026 + 6606</td>
<td>STF 3053 AB</td>
<td>10.884</td>
<td>70.7</td>
<td>15.13</td>
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<td>10.884</td>
<td>23.6</td>
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</tr>
<tr>
<td>00029 + 7122</td>
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<td>10.884</td>
<td>8.7</td>
<td>34.72</td>
<td>1</td>
</tr>
<tr>
<td>00030 + 0723</td>
<td>HJ 3233</td>
<td>10.783</td>
<td>236.5</td>
<td>19.82</td>
<td>2</td>
</tr>
<tr>
<td>00035 + 6041</td>
<td>STI 1261</td>
<td>10.886</td>
<td>165.8</td>
<td>10.90</td>
<td>2</td>
</tr>
<tr>
<td>00042 + 2701</td>
<td>SMA 1</td>
<td>10.605</td>
<td>161.3</td>
<td>13.12</td>
<td>2</td>
</tr>
<tr>
<td>00052 + 3020</td>
<td>STF 3058</td>
<td>10.957</td>
<td>51.3</td>
<td>12.54</td>
<td>1</td>
</tr>
<tr>
<td>00066 + 2901</td>
<td>BU 1338 CD</td>
<td>10.957</td>
<td>209.9</td>
<td>3.02</td>
<td>1</td>
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<tr>
<td>00076 + 0421</td>
<td>GRV 7</td>
<td>10.783</td>
<td>230.5</td>
<td>37.38</td>
<td>1</td>
</tr>
</tbody>
</table>

Notes. C: confirming observation. F: first resolution of a new pair. See Table 1. 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. N = 57−120: 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.)

2.3. Physical or Optical?

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 (rpm). Based on measures in Table 2, five of the pairs are characterized as optical and one as physical. These are flagged in Table 2 with notes.

2.4. Orbit and Linear Calculations

Table 3 presents the mean relative positions for 375 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) to the determination referenced in Column 9. The reference is either to a published orbit or to a determination in the “Catalog of Rectilinear Elements” (Hartkopf et al. 2006), indicated by the letter L. As may be expected, the objects in Table 3 tend to be more frequently observed than those in Table 2. The linear systems (N = 305) have a mean separation of 22′′, and a mean time interval since last observation of only 2.9 yr. The orbit systems (N = 66) have a mean separation of 5′′, and a mean time interval since last observation of only 0.6 yr. Four systems have both orbit and linear solutions, as coverage is as yet insufficient to differentiate between a straight line and a very gradual orbital arc. In nine cases, it is not yet possible to ascertain which of multiple published orbital determinations is to be preferred, so additional residual lines are provided.

2.5. Double Stars Not Found

Table 4 presents 14 systems which were observed but for which no secondary was 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 corrections to the USNO observations or to verify the lack of detection. Notes to some of these pairs highlighting possible reasons for nondetection are appended to the table.
double stars not found

<table>
<thead>
<tr>
<th>WDS Designation</th>
<th>Discoverer</th>
<th>Most Recent Published Observation</th>
<th>Published Magnitude</th>
<th>Notes</th>
</tr>
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<tr>
<td></td>
<td></td>
<td>Date</td>
<td>Position Angle (θ)</td>
<td>Separation (ρ)</td>
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<td></td>
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<td></td>
<td></td>
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<td>00382 + 0305</td>
<td>HDO 32 AB</td>
<td>1868</td>
<td>45</td>
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<tr>
<td>00484 + 0517</td>
<td>HEI 202 AB</td>
<td>1978</td>
<td>353</td>
<td>2.7</td>
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<td>03109 – 0104</td>
<td>CHE 75</td>
<td>1910</td>
<td>221</td>
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<td>04123 – 1820</td>
<td>RSS 71</td>
<td>1976</td>
<td>175</td>
<td>10.6</td>
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<tr>
<td>16243 – 1338</td>
<td>SIN 91 AC</td>
<td>1987</td>
<td>172</td>
<td>6.4</td>
</tr>
<tr>
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<td>SIN 91 AD</td>
<td>1987</td>
<td>14</td>
<td>9.7</td>
</tr>
<tr>
<td>17184 + 0445</td>
<td>SLE 18</td>
<td>1982</td>
<td>333</td>
<td>17.7</td>
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<tr>
<td>19000 – 0233</td>
<td>BRT 487</td>
<td>1897</td>
<td>58</td>
<td>4.2</td>
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<tr>
<td>19359 + 0116</td>
<td>BAL 1523</td>
<td>1901</td>
<td>220</td>
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<tr>
<td>20051 – 1136</td>
<td>H 43</td>
<td>1780</td>
<td>10</td>
<td>25.0</td>
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<tr>
<td>20134 – 1126</td>
<td>J 2304</td>
<td>1942</td>
<td>115</td>
<td>4.0</td>
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<tr>
<td>20231 + 5504</td>
<td>OL 226</td>
<td>1916</td>
<td>41</td>
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<td>21106 – 0837</td>
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<td>22113 + 0317</td>
<td>HJ 957</td>
<td>1916</td>
<td>296</td>
<td>4.0</td>
</tr>
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</table>

Notes. (1) No estimate of magnitude, so it may be beyond the camera capability. (2) The AB pair was seen on two photographic plates by Heintz & Borgman (1984), but the companion was not visible on 164 other plates, nor was it seen on repeated checks with a micrometer. The parallax plates also yield large residuals, leading Heintz & Borgman to suspect variability. (3) Although listed as a measure of 00035 + 3434 OL 77 by Olivier (1920), neither the coordinates nor the measure agreed with that pair, so it was been assigned a new designation. This measure (40°, 73′) could conceivably be a measure of 18547 + 3434 OL 77. (4) Measured twice by Herschel (1829) and Gauchet (1925), the most recent measure is quoted above. No companion seen near either position. Herschel’s measure would imply a separation of 17′′ at approximately the same position angle if both measures are accurate. No companion was seen. (5) This pair has been measured four times (Herschel1829; Burnham1903; Jonckheere1910; Doolittle1923) by reliable observers. It is no doubt real but “lost.”
Herschel, J. F. W. 1829, MemRAS, 3, 177
Hopmann, J. 1960, Mitt. Sternw. Wien, 10, 155
Hopmann, J. 1964, Ann. Sternw. Wien, 26, 1
Jonckheere, R. 1910, J. Astron., 1, 98
Novakovic, B., & Todorovic, N. 2006, Serb. AJ, 172, 21
Olevic, D. 2002, IAU Circ., 147
Olevic, D., & Cvetkovic, Z. 2003, IAU Circ., 150, 1
Olivier, C. P. 1920, Publ. McCormick Obs., 3, 679
Rabe, W. 1961, Veroff. Sternw. Munchen, 6, 113
Zaera, J. A. 1984, IAU Circ., 93, 1
Zirm, H. 2007, IAU Circ., 161, 1
Zirm, H. 2011, J. Double Star Obs., 7, 24