Astronomical Association of Queensland Program of Measurement of Nine Neglected Southern Multiple Stars

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Abstract: Through the first half of 2015 measurements were completed for the following nine southern multiple stars as listed in the Washington Double Star Catalog. Using a 400mm F4.5 Newtonian reflector fitted with a Meade DSI 2 camera and software programme AstroPlanner V2.1 (Rodman) the obtained images were analyzed using Losse’s REDUC software.

Introduction

These latest results are a continuation of the Astronomical Association of Queensland’s program of measuring neglected southern multiple stars. Observed from an approximate latitude of 27°S, target stars were selected from the WDSC that met the criteria of a minimum of fifteen years since the last measure and preferably with very few previous observations.

Method

All images were obtained using a Meade DSI 2 CCD camera coupled to an equatorially mounted 400mm F4.5 Newtonian reflector. Separations and position angles were measured using the software program REDUC (Losse), which is specifically designed to measure double stars, using appropriate images of the target pairs together with images of calibration pairs of known separation and PA; Argyle’s list of calibration pairs was used for this purpose (Argyle, 2004). For this optical/camera (Sony ICX429 752x582 pixel sensor) combination a FOV of approximately 0.2° was calculated using Argyle’s list. The use of REDUC requires input of the image scale of the particular camera/scope combination. By using the same information from the calibration pairs, the image scale mean can be calculated over a number of nights. In this case 10 images themselves consisting of 10 stacked images per night over 7 nights provided the necessary information to calculate the mean. Using this optical assembly to image calibration pairs Beta Tucanae, Theta Serpens, and Omicron Capricorni, raw image scales varied from 0.940 to 0.978, with a mean figure of 0.96260” per pixel. This figure is then used in REDUC for all the target star reductions. The imaging and reduction methods were described in detail in Napier-Munn & Jenkinson 2009.

In order to obtain statistically viable results, the DSI software is used to stack a minimum of 10 individual good quality images as they are acquired, to generate one image for measuring. About 10 such images are obtained per pair per night, plus 3 trailed images with the tracking switched off in order to calibrate the E-W axis in the images. The REDUC software is then used to generate a single average measure for the 10 images. This process is repeated on 6-7 separate nights, generating mean separations and position angles together with standard deviations from which a confidence interval for the measurement can be calculated and a decision made as to whether there has been a statistically significant change in PA or separation.

Results

The results are presented below, in order of increasing RA. For each system, the current WDSC information is first reproduced, including the epoch 2000 position, magnitudes (if known), PA, separation, and year of last measure. The new measures are then given
in tabular form, including the date of measurement, mean, standard deviation, and 95% confidence limits (from the formula \( st_\alpha / \sqrt{n} \), where \( t_\alpha \) is the value of \( t \) for a 2-sided probability level \( \alpha \) (in this case \( \alpha = 0.05 \), \( s \) is the sample standard deviation, and \( n \) is the number of observations). An example of a relevant image used in the measures is included.

A conclusion is then given as to whether the pair has moved or not. This is based on judicious interpretation of three criteria in terms of both PA and separation:

1. t-tests for a single sample mean comparing the new mean PA and separation values with the single values given in the WDSC; \( P \leq 0.05 \) was taken as evidence of movement (that is, the new mean is significantly different to the single value reported in the WDSC, with 95% or more confidence).

2. Whether the last measure as recorded in the WDSC lies within the 95% confidence interval of our new measure (suggesting no movement) or not (suggesting movement).

3. The absolute size of the change; a statistically significant change that is very small is still very small and may not be of practical significance.

Note that in a separate paper (Napier-Munn & Jenkinson 2014) we have shown that the uncertainty in PA increases with decrease in separation, and the uncertainty in separation increases with increase in separation, for reasons discussed in that paper. ‘Uncertainty’ here is defined as the standard deviation of repeated measures.

The mean 95% confidence intervals for the new measures were \( \pm 0.589^\circ \) in PA and \( \pm 0.134" \) in separation. The results are given in Table 1.

Details of each measure are given in Tables 2 through 10 with examples of the measured images.

Acknowledgements

This research has made use of the Washington Double Star Catalogue maintained at the U.S. Naval Observatory.

References


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<td>297.08 8.00 2015.083</td>
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<td>66.35 5.08 2015.043</td>
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<td>B2659 Pyxis</td>
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<td>172.79 18.61 2015.099</td>
<td>Large apparent movement</td>
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<td>315.0 7.0 1932</td>
<td>21.63 12.38 2015.099</td>
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<td>321.0 7.6 1930</td>
<td>324.34 6.55 2015.178</td>
<td>Movement</td>
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<td>317.0 16.0 1944</td>
<td>325.97 14.81 2015.178</td>
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<td>184.0 11.3 1922</td>
<td>151.60 47.63 2015.303</td>
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* Epochs of new measures given in Besselian years as the average of the observations making up the measure.
... Measurement of Nine Neglected Southern Multiple Stars

Table 2. Measurements of BU 1419 BC.

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COMMENTS: Possible slight movement in PA over the last 112 years.

Table 3. Measurements of HO 554 AC.

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COMMENTS: Little movement evident since 1929.
... Measurement of Nine Neglected Southern Multiple Stars

Table 4. Measurements of B 2659.

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COMMENTS: Large apparent movement in both axes since the only previous measurement in 1932 warrants further investigation.

Table 5. Measurements of B 2263.

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COMMENTS: Poor seeing on 21 February 2015 – results deleted from calculation of mean. Considerable movement apparent since the only previous measure in 1932.
... Measurement of Nine Neglected Southern Multiple Stars

Table 6. Measurements of CPO 327.

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<th>DEC. -43 33</th>
<th>PA. 321.0°</th>
<th>SEP. 7.6&quot;</th>
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<td>325.720</td>
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<td>7 March 2015</td>
<td>10</td>
<td>322.320</td>
<td>6.667</td>
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<tr>
<td>12 March 2015</td>
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<td>323.680</td>
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**COMMENTS:** Increase in PA and decrease in separation appear consistent with the two previous measures in 1902 and 1930.

Table 7. Measurements of RST 3746 AB.

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<td>14.774</td>
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**COMMENTS:** Changes in PA & separation consistent with two previous measures in 1937 & 1944.
... Measurement of Nine Neglected Southern Multiple Stars

Table 8. Measurements of ARA 1790.

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<td>P(t) movement</td>
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COMMENTS: Large increase in separation over 93 years. Change in PA relative to separation change seems viable.

Table 9. Measurements of RSS 370.

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<tr>
<td>Standard dev.</td>
<td></td>
<td>0.927</td>
<td>0.072</td>
<td>Standard dev.</td>
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<td>0.927</td>
<td>0.072</td>
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<tr>
<td>95% CI +/-</td>
<td></td>
<td>0.857</td>
<td>0.067</td>
<td>95% CI +/-</td>
<td></td>
<td>0.857</td>
<td>0.067</td>
</tr>
<tr>
<td>P(t) movement</td>
<td></td>
<td>0.003</td>
<td>0.000</td>
<td>P(t) movement</td>
<td></td>
<td>0.003</td>
<td>0.000</td>
</tr>
</tbody>
</table>

COMMENTS: Possible small increase in PA since the only previous measure in 1976.
... Measurement of Nine Neglected Southern Multiple Stars

Table 10. Measurements of RSS 386.

<table>
<thead>
<tr>
<th>RSS 386</th>
<th>RA. 15 48.6</th>
<th>DEC. -65 14</th>
<th>Last Measure 1974</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triangulum Aust.</td>
<td>MAG. 8.6 &amp; 12.0</td>
<td>PA. 270°</td>
<td>SEP. 10.3°</td>
</tr>
<tr>
<td>Date</td>
<td>No. images</td>
<td>PA&quot;</td>
<td>Sep&quot;</td>
</tr>
<tr>
<td>16 April 2015</td>
<td>10</td>
<td>14.460</td>
<td>10.246</td>
</tr>
<tr>
<td>17 April 2015</td>
<td>10</td>
<td>14.330</td>
<td>10.388</td>
</tr>
<tr>
<td>18 April 2015</td>
<td>10</td>
<td>13.590</td>
<td>10.285</td>
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<tr>
<td>24 April 2015</td>
<td>10</td>
<td>15.140</td>
<td>10.159</td>
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<tr>
<td>04 May 2015</td>
<td>10</td>
<td>14.870</td>
<td>10.378</td>
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<tr>
<td>05 May 2015</td>
<td>10</td>
<td>15.400</td>
<td>10.319</td>
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<tr>
<td>08 May 2015</td>
<td>10</td>
<td>14.610</td>
<td>10.364</td>
</tr>
<tr>
<td>Mean</td>
<td>14.629</td>
<td>10.306</td>
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</tr>
<tr>
<td>Standard dev.</td>
<td>0.593</td>
<td>0.083</td>
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</tr>
<tr>
<td>95% CI +/-</td>
<td>0.549</td>
<td>0.077</td>
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</tr>
<tr>
<td>P(t) movement</td>
<td>0.000</td>
<td>0.864</td>
<td></td>
</tr>
</tbody>
</table>

COMMENTS: No change in separation makes large change in PA questionable over the last 41 years.